How great comets have shaped history p. 22

ILLUSTRATED: Explore Jupiter's moons p. 56

February 2008

Astronomy®

The world's best-selling astronomy magazine

Journey to the center of the Milky Way

Astronomers target the black hole at the heart of our galaxy p. 28

Stars orbit wildly just light-hours from the massive black hole at our galaxy's core.

BREAKING NEWS

Latest images from Mars p. 52

What it's like to observe from the darkest skies p. 64

www.Astronomy.com

AND MORE!

On the trail of hydrogen's heavy sibling p. 34

Meade's mySKY teaches you the stars p. 66

View winter's forgotten star clusters p. 60

$5.95 U.S. • $6.95 CANADA

0 72246 46770 1 02

Vol. 36 • Issue 2

MEADE

mySKY™

YOUR PERSONAL GUIDE FOR SKY EXPLORATION

get closer to more than just the stars

A shared moment of discovery can bring families together like no other experience. Now, you can create those moments every night with mySKY — your personal guide for sky exploration that takes you and your family on a fascinating tour of the cosmos.

Point at the sky and shoot. mySKY immediately describes — in exciting audio/visual detail — what you're looking at from its database of over 30,000 planets, stars constellations, nebulas and galaxies.

Price: Just $399

EASY TO USE Just point and shoot – GPS and other technologies do all the rest. Perfect for the kids in every family or anyone that's ever been curious about the night sky.

THRILL OF EXPLORATION Pick a celestial object in the sky and immediately learn about it in exciting detail. Or use the Tour Mode to enjoy a guided tour of the best objects for viewing on any given night.

EXCITING MULTI-MEDIA Bring the sky to life with vivid full-color display featuring video, stunning astrophotography, entertaining audio descriptions, sky maps, mythology, folklore, fun facts and much more.

So use the attraction of the stars and mySKY to bring your family and friends together tonight. To learn more about the mySKY experience visit www.meade.com/mysky.

To purchase, call one of the authorized mySKY dealers listed below.

OPTICS PLANET (800.504.5897) • OPT CORP (800.338.9638) • TELESCOPES.COM (800.958.6030)
ASTRONOMICS (800.356.6603) • WOODLAND HILLS TELESCOPE (877.626.3233) • SCOPE CITY (800.235.3344)
ANACORTES TELESCOPES (888.996.3233) • CANADA - KHAN SCOPE (800.580.7160)

©2007 Meade Instruments Corporation. Utility Patent U.S. 5,311,203 and other Patents Pending. Specifications subject to change without notice. 30-07169

Tele Vue®

"is"

Telescopes

"A Wide-Field Imager's Dream Scope" Read the Astronomy test report on the Tele Vue-NP101is in the January 2008 issue!

"The Ultimate Telescope for Astrophotography?" Read the S&T test report on the Tele Vue-NP127is in the July 2007 issue!

The Rosette Nebula dual frame mosaic image taken with Tele Vue-NP127is and Apogee Alta U9000 CCD camera by Tim Puckett and Adam Block.

While astro-imaging isn't quite point-&-shoot photography, it doesn't get any easier than with the Tele Vue Imaging System—Telescopes and accessories designed to work with the widest variety of cameras, filter wheels, and software. Take the hassle out of hunting around for spacers, adapters, motorized focusers, computer interfaces etc. It's all available in the Imaging System!

Imaging System Accessories include: model specific focal reducers and reducer/flatteners, electric focus driver, Focusmaster computer interface, Digital Indicator Kit focus position reader, extension tubes, camera adapters and more at www.TeleVue.com

$6,285

Tele Vue-NP127is
4-element, Nagler-Petzval APO
5", f/5.2, E.F.L. 660mm
4.5°/4.0° max. FoV Photo/Vis.
Non vignetting, dual speed focuser
with Image Plane Tilt Compensation

$3,585

Tele Vue-NP101is
4-element, Nagler-Petzval APO
4", f/5.4, E.F.L. 540mm
5.5°/4.9° max. FoV Photo/Vis.
Non vignetting, dual speed focuser
with Image Plane Tilt Compensation

$2,685

Tele Vue-NP102iis
2-element APO
4", f/8.6, E.F.L. 880mm
3.5°/3.0° max. FoV Photo/Vis.
Non vignetting, dual speed focuser
with Image Plane Tilt Compensation

$1,525

Tele Vue-60is
2-element APO
2.4", f/6, E.F.L. 360mm
4.3°/7.2° max. FoV Photo/Vis.
2.0", Dual speed focuser

Instead of a rose, we're giving you a carrot.
10% off all Tele Vue telescopes!

Prices subject to change without notice.

Tele Vue® Visionary

32 Elkay Drive, Chester, New York 10918
845.469.4551 www.TeleVue.com

ORION®
TELESCOPES & BINOCULARS

ORION 32 YEARS

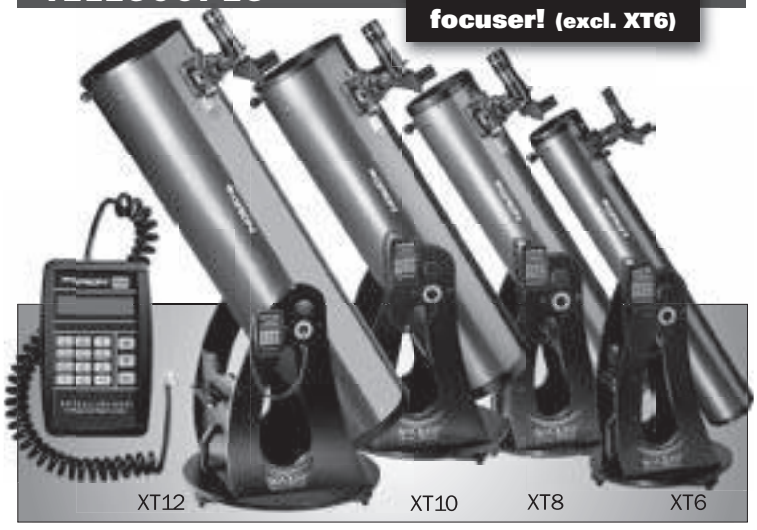
Select from over 1,000 products

(800) 447-1001
OrionTelescopes.com

EVERYTHING FOR THE AMATEUR ASTRONOMER — DELIVERED DIRECT

TELESCOPES

New Crayford-style focuser! (excl. XT6)



SkyQuest™ XT IntelliScope® Dobsonians

Space is infinite. Your patience is not. Avoid tedious truss-tube designs and get a Dob that's faster to set up, has a solid-wall tube for superior contrast, has altitude tension adjustment for optimal balance, is amply portable, and allows *computerized pointing* to 14,000+ objects.

XT12 IntelliScope . . $1,119.95* **XT8 IntelliScope . . . $619.95**
X10 IntelliScope . . . $789.95 **XT6 IntelliScope . . . $499.95**

* Prices *INCLUDE* optional Computerized Object Locator with 14,000-object database.

Computerized EQ Telescopes

Orion® SkyView™ Pro 8 EQ GoTo Reflector
Terrific deep-space probe with f/4.9 parabolic optics and auto-pointing GoTo system.
$1,079.95

Orion® Sirius™ 80ED EQ-G Apo Refractor
An outstanding instrument for CCD or DSLR imaging.
$1,299.95 with Dual-Axis Controller
$1,599.95 with GoTo Controller

Orion® Atlas™ 11 EQ-G Schmidt-Cassegrain
Take your deep-sky aspirations to the limit.
$2,849.95 with Dual-Axis Controller
$3,149.95 with GoTo Controller

Great Scopes for Astro-Imaging

Orion® 6" Imaging Reflector OTA
With its large 6" (150mm) parabolic mirror, this compact f/5.0 astrograph is optimized to fully illuminate the imaging chip of Orion StarShoot CCD cameras and most digital SLRs, rendering exquisite detail even with short exposures.
$379.95

Orion® Premium 102mm ED Refractor
The Premium 102ED was designed for astro-imaging. Its 714mm focal length and slightly faster focal ratio of f/7.0 deliver high magnification and bright, high-contrast images with modest exposure times. The 102ED sets a new standard for quality and performance in the $1,000 price category.
$999.95

BINOCULARS

Resolux™ Astronomical Binoculars
They're our new favorite astro binocs, combining fully multi-coated BAK-4 prism optics with military-spec mechanical construction. They are also 100% waterproof! You'll enjoy pinpoint stars and exceptional contrast. Available in 50mm and 70mm apertures.

7x50 $279.95
10x50 $279.95
10.5x70 $369.95
15x70 $369.95

BT70™ Premium Binocular Telescope
Probe the night sky with 3D-like depth of field! The BT70 features air-spaced 70mm lenses, full multi-coatings, and BAK-4 prisms. Interchangeable 20x eyepieces; convenient 90° eyepiece angle. All-metal body has retractable lens shades and carrying handle.
$649.95

ACCESSORIES

Orion® Q70™ 2" Super-Wide Field Eyepieces
Gargantuan 70-degree apparent field of view and fully multi-coated, 5-element optics make Q70s the best choice in affordable premium 2" eyepieces. Three focal lengths: 26mm, 32mm, 38mm.
$99.95 each

StarShoot™ Deep Space Color Imager II
This next-generation StarShoot Deep Space Imager has a bigger chip and thermoelectric cooling. Includes MaxIm DL Essentials software.
$699.95

Edge-On™ Flat Field Eyepieces
Their 5- or 6-element design eliminates field curvature for distortion-free images. And, they're parfocal.
$99.95 each

SkyLine™ Deluxe Green Laser Pointer
Upgraded to use electronic feedback regulation to ensure ultra-stable beam intensity compared to other green lasers on the market.
$99.95

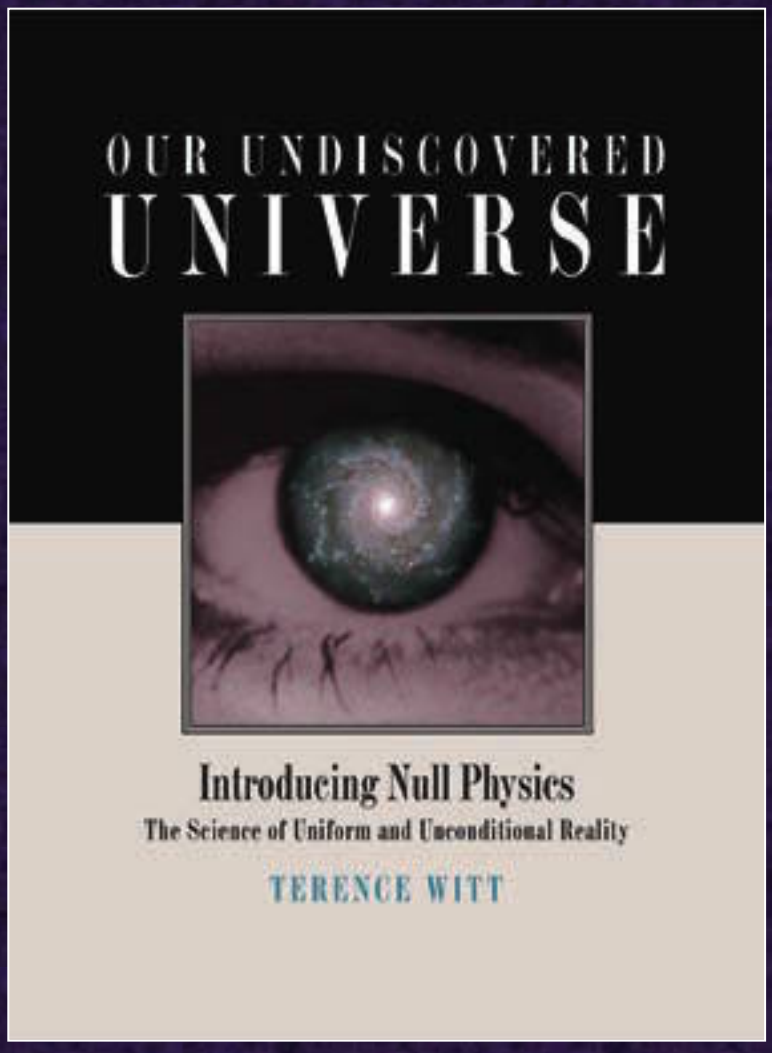
FREE Color Catalog!
Call toll-free (800) 447-1001 or request it online.
Prices subject to change

We Treat Our Customers Like Stars!
24 Hour Toll-Free Orders: (800) 447-1001
OrionTelescopes.com

MONEY-BACK 100% Satisfaction GUARANTEE

Information/Advice:
(800) 676-1343

IMAGINOVA



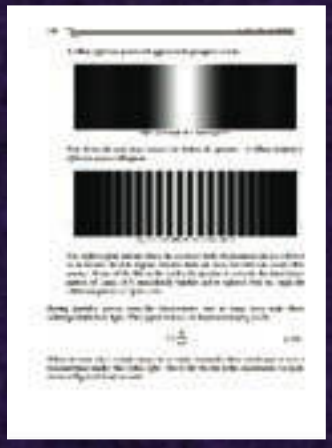
Physicists sometimes wonder if a new theory might emerge that makes quarks, the Big Bang, and superstrings completely obsolete.

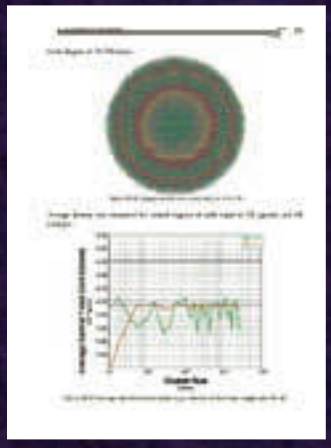
They don't need to wonder anymore.

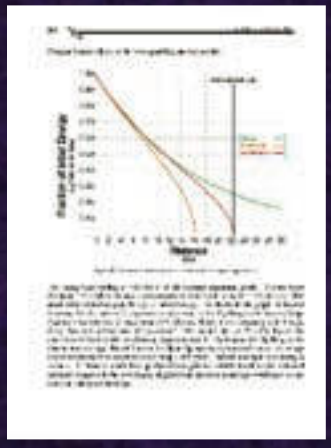
Our Undiscovered Universe probes nature's secrets with a depth and clarity never before imagined.

- *Unified*
- *Rational*
- *Revolutionary*
- *Empirically validated*

100 years ago, Einstein found a small part of the universe's four-dimensional geometry. Null Physics reveals the rest of it.







Are you ready for an incredible journey?

nullphysics.com

479 pages, hardcover with dust jacket, $59. Available at nullphysics.com. © 2007 Aridian Publishing Corporation, (877) 274-3426

ASTRONOMY MAGAZINE 35th ANNIVERSARY

How great comets have shaped history p. 22
ILLUSTRATED: Explore Jupiter's moons p. 56
February 2008
Astronomy
The world's best-selling astronomy magazine
Journey to the center of the Milky Way
Latest images from Mars p. 52
BREAKING NEWS
Astronomers target the black hole at the heart of our galaxy p. 28
What it's like to observe from the darkest skies p. 64
www.Astronomy.com
AND MORE!
On the trail of hydrogen's heavy sibling p. 34
Meade's mySKY teaches you the stars p. 66
View winter's forgotten star clusters p. 60

DON DIXON FOR *ASTRONOMY*

ON THE COVER

22 How comets shaped history

56 Illustrated: Explore Jupiter's moons

28 Journey to the heart of the Milky Way

52 Where has all the water gone?

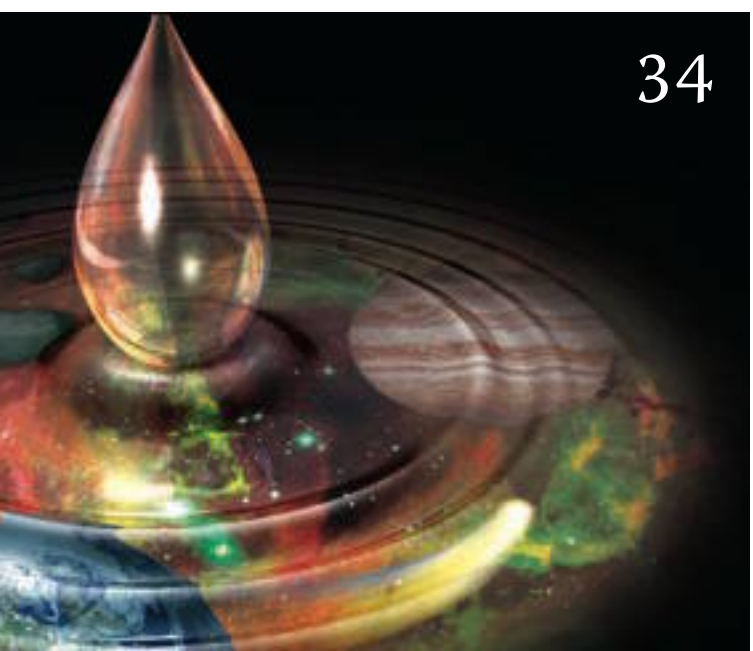
64 The darkest sky under the stars

60 Observe winter's forgotten star clusters

66 Meade's mySKY teaches you the stars

34 On the trail of hydrogen's heavy sibling

TONY AND DAPHNE HALLAS



ASTRONOMY: ROEN KELLY

VOL. 36, NO. 2

Astronomy

The world's best-selling astronomy magazine

february 2008

8 **This month in *Astronomy***
Astronomy magazine's iStar Party

10 **Letters**

11 **Web talk**

12 **Bob Berman's strange universe**
Other dimensions

14 **Stephen James O'Meara's secret sky**
Orion's phantom loop, part 1

16 **Astro news**
Hubble peers into a Milky Way starburst, Harmony arrives at the space station, and a youthful galaxy grows up

22 **How comets shaped history**
In ancient skies, a comet's sudden appearance provided both spectacle and portent — and savvy leaders took advantage. **RICHARD JAKIEL**
WEB EXTRA: Check out details on 26 great comets.

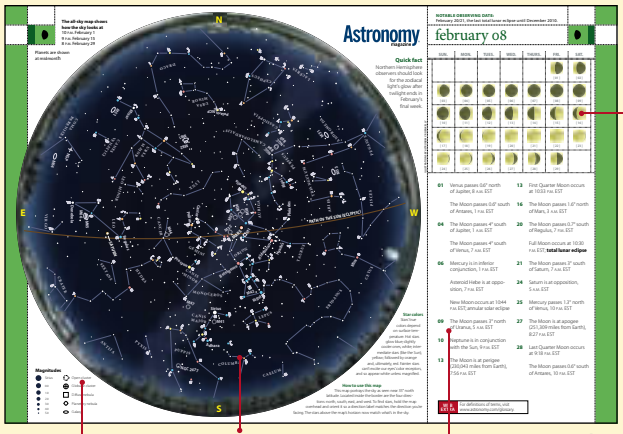
28 COVER STORY

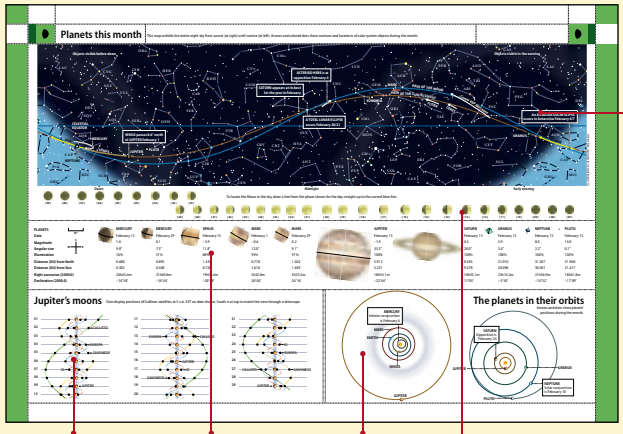
Journey to the heart of the Milky Way
Astronomers know a supermassive black hole anchors our galaxy's core. But they struggle to understand the origins of fast-moving stars that swarm it. **JOHN DVORAK**
WEB EXTRA: UCLA's Brian Hansen talks about the galactic core.

34 **On the trail of hydrogen's heavy sibling**
With twice the mass of ordinary hydrogen, deuterium plays a weighty role in trying to comprehend the early universe, galactic evolution, and life's extent. **BRUCE DORMINEY**

40 **The sky this month**
Shadow play on the Moon
MARTIN RATCLIFFE AND ALISTER LING

EXCLUSIVE PULLOUT STAR CHARTS: Your guides for observing this month's night sky (p. 40)





52 **Where has all the water gone?**
New results from Mars Reconnaissance Orbiter suggest the Red Planet's past may not have been so warm and wet after all. **RICHARD TALCOTT**
WEB EXTRA: See more great MRO images.

56 **Illustrated: Explore Jupiter's moons**
Tenuous dust rings, glowing gas clouds, and a ring of plasma arise from Jupiter's closest moons.
FRANCIS REDDY; ILLUSTRATION BY ROEN KELLY

58 **Ask Astro**
- Do photographs of Mars show change over time?
- Do black holes swallow neutrinos?
- Why do neutron stars have small diameters?
- Are galaxies moving away from or toward one another?

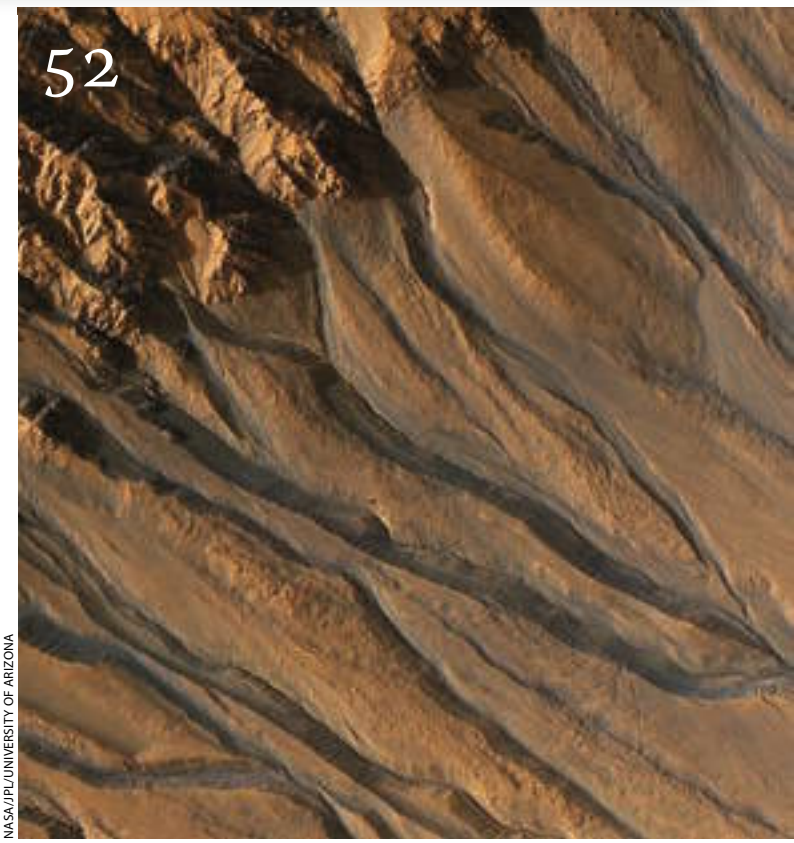
60 **Observe winter's forgotten star clusters**
Begin your observing year with 16 bright, but little-known, open clusters. **STEVE COE**
WEB EXTRA: Find 12 more winter open clusters.

64 **The darkest sky under the stars**
Observing and imaging are top priorities at Arizona Sky Village, a remote community that may be amateur astronomers' paradise. **MICHAEL E. BAKICH**

66 **Meade's mySKY teaches you the stars**
Beginning astronomers take note: You can identify celestial objects like a pro. **MIKE D. REYNOLDS**

68 **Glenn Chaple's observing basics**
Surf the skies
WEB EXTRA: Check out *Astronomy* editors' favorite web sites.

70 **Phil Harrington's binocular universe**
Meet the colorful Gemini twins
WEB EXTRA: Discover more Gemini star clusters.

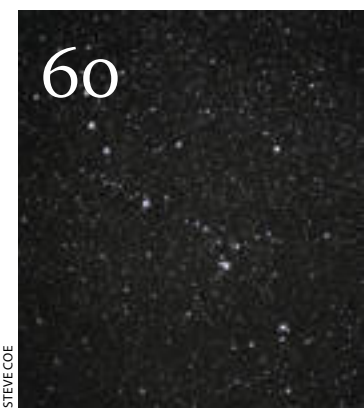


NASA/JPL/UNIVERSITY OF ARIZONA

72 **New products**

73 **Advertiser index**

78 **Reader gallery**
Comet Holmes lights up for photographers around the world.



STEVE COE

WEB EXTRA Visit **Astronomy.com/toc** for bonus material — it's exclusive to *Astronomy* magazine subscribers.

BY DAVID J. EICHER

Astronomy magazine's iStarParty

Astronomy is a lonesome activity. Yes, we celebrate star parties — those majestic, dark nights under great skies with dozens of excited amateurs running about — and club meetings where we can compare notes on favorite deep-sky objects. On many nights, however, observing the heavens under a dark sky means a date between you and your telescope. For most of the hundreds of youthful nights I observed out in a cornfield near my house in Ohio, my sole companion was my dog, Oscar, and maybe some furry, wild critters rustling through the nearby brush.

Technology is rapidly changing the world, and astronomy is no exception. What if you could be out there in the field, alone with your telescope, yet participate in a worldwide star party any night? The key is to connect observers and telescopes via the Internet. You could instantly share details about the same galaxy you're looking at with an observing friend across the country — or the world.

In hallway discussions here at *Astronomy*, we've come to call this vision iStarParty. It's the brainchild of James Schweder, an amateur astronomer and also a vice president at Kalmbach Publishing Co., *Astronomy*'s parent company.

iStarParty would allow you to remotely control and pass between telescopes images, descriptions, and locations of astronomical objects via the Internet. Controlled by one Internet-enabled telescope and a computer, a person could conduct a star party from his or her telescope and involve many other observers at remote locations.

iStarParty is a concept, not a ready-to-go product. To make it real would require modifications to telescopes and mounts, and some cooperative efforts by telescope manufacturers. It has the potential to change the hobby's landscape, to bring the Internet generation to the telescope. But is it the future? That's up to you.

I'm throwing this idea out to the largest group of amateur astronomers on the planet, *Astronomy*'s readers, to get your reaction. Would you participate in this new world of observing? Would you want to observe online with friends and have a real-time interactive chat room connected to your scope so you could immediately discuss observations?

If iStarParty develops, *Astronomy* magazine editors will be heavily involved in holding online star parties with you. What fun we could have!

But first we need to know how this idea strikes you and whether it interests you, because the technological hurdles would lie with telescope manufacturers.

Would you be excited by this new way of observing and participate in *Astronomy*'s iStarParty? E-mail me at editor@astronomy.com to let me know what you think.

Yours truly,

David J. Eicher
Editor

Astronomy

Volume 36, Number 2

Editor David J. Eicher
Art Director LuAnn Williams Belter

EDITORIAL STAFF
Managing Editor Dick McNally
Senior Editors Michael E. Bakich, Francis Reddy, Richard Talcott
Associate Editors Laura Baird, Laura Layton, Daniel Pendick
Assistant Editor Jeremy McGovern
Editorial Associate Valerie Penton
Editorial Intern Megan McChain

ART STAFF
Graphic Designer Chuck Braasch
Illustrators Theo Cobb, Roen Kelly, Jay Smith
Production Coordinator Joni Keller

CONTRIBUTING EDITORS
Bob Berman, Glenn F. Chaple, Jr., Phil Harrington, David Healy, Ray Jayawardhana, Alister Ling, Steve Nadis, Stephen James O'Meara, Tom Polakis, Martin Ratcliffe, Mike D. Reynolds, John Shibley, Raymond Shubinski

EDITORIAL ADVISORY BOARD
Buzz Aldrin, Marcia Bartusiak, Timothy Ferris, Alex Filippenko, Adam Frank, John S. Gallagher III, William K. Hartmann, Paul Hodge, Anne L. Kinney, Edward Kolb, Stephen P. Maran, S. Alan Stern, James Trefil

[Kalmbach Publishing Co.]
President Gerald B. Boettcher
Vice President, Editorial, Publisher Kevin P. Keefe
Vice President, Advertising Scott Stollberg
Corporate Art Director Maureen M. Schimmel
Managing Art Director Michael Soliday
Production Manager Annette Wall
Corporate Circulation Director Michael Barbee
Group Circulation Manager Paul Daniel
Single Copy Sales Director Jerry Burstein
Circulation Coordinator Sarah Zemplinski

ADVERTISING DEPARTMENT
(888) 558-1544
Advertising Director Scott Bong
Advertising Sales Representatives
Craig Greuel, cgreuel@kalmbach.com
Ken Kozerski, kkozerski@astronomy.com
Ad Services Representative Katie Wendt
kwendt@kalmbach.com

RETAIL TRADE ORDERS AND INQUIRIES
(800) 558-1544, ext. 818; outside the U.S. and Canada: (262) 796-8776, ext. 818

CUSTOMER SALES AND SERVICE
(800) 533-6644; fax: (262) 796-1615
customerservice@kalmbach.com

SPECIAL E-MAIL ADDRESSES
Ad Sales adsales@astronomy.com
Ask Astro askastro@astronomy.com
Books books@astronomy.com
Letters letters@astronomy.com
Products products@astronomy.com
Reader gallery readergallery@astronomy.com

Editorial phone: (262) 796-8776; advertising: (888) 558-1544; customer service & sales: (800) 533-6644; outside the U.S. and Canada: (262) 796-8776, ext. 421, Monday through Friday, 8:30 A.M. to 5 P.M. CT, Fax: (262) 796-1615; E-mail: customerservice@kalmbach.com. Please include your name, mailing address, and telephone number with any correspondence. Copyright © 2007 Kalmbach Publishing Co., all rights reserved. Material in this publication may not be reproduced in any form without permission. Printed in the U.S.A. Allow 6 to 8 weeks for new subscriptions and address changes. Subscription rate: single copy: $5.95; 1 year $42.95, 2 years (24 issues) $79.95, 3 years (36 issues) $114.95; Canadian & foreign: 1 year $50.95, 2 years $95.95, 3 years $138.95. Payable in U.S. funds drawn on U.S. Banks. (Canadian price includes GST.) Expedited Delivery Service Surcharges: Domestic 1st Class $30 per year, Canadian air $30 per year, Foreign air, $60 per year. BN 12271 3209 RT. Not responsible for unsolicited materials.

astronomics™

The optical center of the known Universe.™

Anyone can sell you a telescope. We'll sell you the right telescope.™

At *astronomics,* our family-owned business has helped people choose the right telescope since 1979. Our friendly people (with a total of over *150 years* of experience using and selling telescopes) will take the time to help *you* pick the telescope that best fits your needs (and your budget).

TMB triplet apo refractors start under $1000.

You get your choice with a **TMB Optical** 80mm f/6.3 triplet apo refractor. First choice, the aluminum tube **TMB-80**, right, for $995. Never before has a genuine TMB apo been so attractively priced.

Like all TMB refractors, the TMB-80 uses premium FPL-53 ED glass in its fully multicoated apochromatic triplet lens. The aluminum tube TMB-80 has a rotating 2" Crayford focuser, 1.25" and 2" compression ring eyepiece holders, and a *free* $120 value Astro-Tech 2" dielectric star diagonal. A true TMB apo refractor for under $1000? Wow!

Second choice, the **TMB-80CF**, above left. Its 80mm triplet FPL-53 apo optics are in a unique, lightweight (only 4.35 pounds), and incredibly strong carbon fiber body. It even includes a Starlight Instruments *Feather Touch* 2" dual-speed Crayford focuser.

The very compact 92mm f/5.5 **TMB-92** triplet apo, below, fills the void left by the discontinued 90mm Astro-Physics Stowaway (a legendary scope that sells for up to $6000 on the used market). But you won't pay $6000 for the TMB-92. This fast f/ratio TMB is only $1999. The TMB-92 has a collimatable lens cells and a famous *Feather Touch* 2.7" dual-speed rotating rack and pinion focuser.

For answers to your telescope questions, visit the forums at *www.cloudynights.com*

Is a Celestron CGE Schmidt-Cassegrain go-to ideal for astrophotography?

Astrophotography with a fork-mounted go-to scope has drawbacks. You usually can't use an altazimuth fork mount to take long exposure photos without adding a costly equatorial wedge or field derotator.

But, use a wedge and you often can't image near the celestial pole or southern horizon because the OTA hits the mount, and tube vibrations become a problem. Use a field derotator and you lose periodic error correction and often can't image near the zenith. And setting up a large fork mount usually requires two people.

Celestron CGE German equatorial 8" to 14" go-to scopes solve these problems.

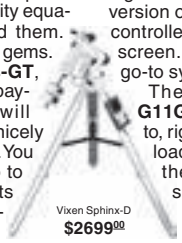
The CGE mount can reach all parts of the sky without adding an expensive wedge or field derotator. Even the big 14" CGE1400 can be set up by only one fit person. And German mounts are virtually vibration-free.

Celestron CGE go-to Schmidt-Cassegrains have state-of-the-art Starbright XLT multicoatings and start at $3654. They come as complete systems, or you can buy just the mount to use with your own optics.

Need a quality go-to mount for your optics? Losmandy, Orion, and Vixen have you covered.

If you have quality optics, such as a TMB apo refractor or a big SCT optical tube, you want a quality equatorial mount to hold them. Here are some GEM gems.

The **Orion Atlas-GT**, left, has a 40 lb. payload capacity. It will carry your optics nicely for only $1499.95. You can train it to go to celestial objects with 1 arc minute accuracy!



The **Vixen Sphinx-D**, below left, has a big 50 lb. payload capacity and the latest version of the famous Starbook controller with a full-color LCD screen. It's a truly advanced go-to system for $2699.

The $3195 Losmandy **G11GT** with Gemini go-to, right, has a 60 lb. payload capacity. It has been the favorite mount of serious astrophotographers for many years.

The *Hot Product* Celestron SkyScout. In stock now.

The **Celestron SkyScout** is the multiple award-winning *2007 Hot Product* that started it all.

SkyScout puts you on a first name basis with the universe. This non-magnifying GPS-based hand-held personal planetarium identifies and leads you to *every* celestial object visible to your unaided eye. You can hear their stories through earbuds or read them on a scrolling 5-line text and graphics display.

The $124.95 **Orion SkyLine** laser mounts on the SkyScout and points a green line at sky objects as you identify them so all can see where they are.

Better do in dew before dew do in you.

AstroZap is well-known for their flexible plastic and aluminum dew shields that slow dew formation. Now, their dew heaters and DC controllers *eliminate* dewing.

The weak dollar makes Astrozap heaters far less expensive than big-name imported dew heaters.

astronomics. No pushy salespeople. No inexperienced help. Just honest advice from telescope experts with years of practical observing experience, the time to make sure you get the right telescope and accessories, plus a good price you can afford. Call us toll-free at (800) 422-7876 and find out for yourself.

A $69.95 Astro-Tech *Hot Product* best buy.

The **Astro-Tech** *dielectric* 1.25" star diagonal is a *Sky & Telescope Hot Product for 2007*. It has 99% reflectivity *46-layer* dielectric mirror coatings deposited on its 1/10th wave BK7 optical glass substrate. Its brass compression ring eyepiece holder won't scratch your eyepieces. At only $69.95, this certainly *is* a best buy. And it's one of *five* value-priced dielectric diagonals from Astro-Tech.

The only thing better than Meade ETX optics . . . are the affordable Meade ETX prices.

The 3.5" aperture **Meade ETX-90PE** go-to telescope at only $699, and the 5" **ETX-125PE** at only $999, are your affordable passports to over 30,000 solar system and deep space wonders.

It doesn't take a rocket scientist to take advantage of the superb Maksutov-Cassegrain optics on an ETX. Simply tell your ETX your zip code. *Level North Technology* automatically moves to two alignment stars. Center the red dot finder on those stars. Tell your ETX which of the 30,000+ objects in its memory you want to see and your ETX takes you there *automatically.*

Your Meade ETX comes with an adjustable height tripod, red dot finder, 26mm Super Plössl eyepiece, and your choice of a classic blue optical tube or one with a full-color deep space image.

The best Celestron 8 cost $1295 in 1979. Today, an even better *go-to* Celestron 8 is only $1399.

When we started business in '79, a Celestron C8 cost $1295 and was an incredible bargain. That C8 (state-of-the-art in 1979) would cost $3709.28 in today's inflated dollars – but wouldn't have the go-to computer, multicoatings, DC drive, or Plössl eyepiece of today's $1399 **Celestron NexStar 8 SE.**

But it *would* still have Celestron's superb Schmidt-Cassegrain optics. That's one important benefit for you that hasn't changed over the years.

If you think about it, a Celestron's cost has actually *deflated* over the years. You get more telescope performance, but you pay less money, because many of today's advanced features were unavailable at *any* price only a few short years ago. Features like the no-guesswork *SkyAlign* go-to computer that finds objects automatically to make astronomy as easy as 1-2-3, and Starbright XLT multicoatings for brighter images and higher contrast.

Is a **Celestron NexStar SE** a great value? *Absolutely!*

NexStar 4 SE, 4" Maksutov **$599**
NexStar 5 SE, 5" Schmidt **799**
NexStar 6 SE, 6" Schmidt **999**
NexStar 8 SE, 8" Schmidt **1399**

Point, click, identify, locate. The sky doesn't get any easier than this.

Not only does the **Meade mySky** electronic travel guide to the heavens locate and identify 30,000 celestial objects for you with point and click ease, it also shows you full-color images of many of them. You see and hear exciting multimedia presentations on its 480 x 234 pixel LCD screen and through its high fidelity earbuds, with color video, audio, still images, sky maps, and text.

An optional $29.95 cable connects the GPS-based mySky to your Meade AutoStar-equipped scope for point and go-to viewing, or to add GPS to your non-GPS computerized Meade scope.

The Coronado PST. Seeing sunspots is just the start.

The **Coronado PST** (Personal Solar Telescope) shows you much more than just the sunspots you see with an ordinary solar filter. For less than cost of some premium eyepieces, the H-alpha filter in the PST shows you the ever-changing drama of solar flares and prominences exploding before your eyes.

The PST includes a 40mm refractor with a full-time built-in solar filter, a safe built-in Sun finder, and a 20x eyepiece.

Competitors? At $1195 there are none!

No competitive scope gives you the same full array of standard features that you get for only $1195 with the **Astro-Tech AT102ED** ED refractor – a rotating Crayford focuser with a genuine *Feather Touch* dual-speed micro-focuser custom-made for the AT102ED*; an illuminated multiple reticle finder*; a locking hard case*; dual split hinged tube rings with a detachable 8" dovetail*; 102mm f/6.95 ED doublet optics; retractable dew shield; non-marring 1.25" and 2" brass compression ring eyepiece holders; a *two-year* warranty*; and more.

All of the features listed above that are marked with an asterisk (*) are either optional or are not available with some or all of the competitive scope models.

Competitive scopes? Sorry, but they just can't compete.

astronomics™

Our 29th year of friendly service, reliable advice, and money-saving prices.

680 24th Avenue SW, Norman, OK 73069

PHONE HOURS: 8 to 9 CST Mon - Fri, Sat 12 to 5. STORE HOURS: 9 to 5 Mon - Fri, Sat by appointment.

Toll-Free Telephone: **(800) 422-7876** On the web at: **www.astronomics.com**

24-Hour FAX line: **(405) 447-3337** Our e-mail address: **questions@astronomics.com**

Prices, special offers, and specifications are current as of 11/10/07, but are subject to change.

Mastercard, Visa, Discover, American Express.

Hubble triumph

I just took your weekly web-site poll, asking "Which is the most impressive space mission in the last five years?" The available choices were all significant accomplishments, but I chose "other" as my answer. For me, by far the most impressive mission was capturing the Hubble Ultra Deep Field image with an aging space telescope. **— JUSTIN SOUTAR,** HUNTSVILLE, OHIO

For more images from the Hubble Space Telescope, go to hubblesite.org. Also, watch www.Astronomy.com for continuing news coverage of Hubble's exploits and vote in our weekly polls. **— *ASTRONOMY* EDITORS**

AN ENLARGED PORTION of the Hubble Ultra Deep Field shows ancient galaxies in stunning detail. NASA/ESA/S. BECKWITH (STScI)/HUDF TEAM

Artful science

In "Jupiter up close and personal" (August 2007), the caption on page 33 describing Europa rising above Jupiter reads, in part, "This image is one of a handful taken primarily for artistic, instead of scientific, purposes." A scientist who cares nothing for art renders the pursuit of knowledge utterly stillborn. Are young people inspired to pursue astronomy because of dust-particle impact measurements? Or does the inspiration come from being drawn to the image of a moon rising above the horizon of a distant planet?

Alan Stern's article on the New Horizons encounter with Jupiter was wonderful. But how much more wonderful would it be if the image on page 33 plants the seed that someday produces a new Gerard Kuiper, Carl Sagan, or Eugene Shoemaker? **— MICHAEL WOLFF,** NORTH CHARLESTON, SOUTH CAROLINA

Pedestrian astronomy

I am the subject of Phil Scott's article about sidewalk astronomy, "Come see the Moon!" (October 2007). Thank you for the wonderful way he brought sidewalk astronomy to your readers' attention. Public service sidewalk astronomy — John Dobson's inspired and worthy challenge to all amateur astronomers — is the only way most people will ever get to see through a telescope and better understand "where we are."

Please share with you readers two helpful web sites, www.sidewalkastronomers.us and www.telescopepictures.com, where they can learn more about sidewalk astronomy and John Dobson. **— JEFFREY JACOBS,** RYE, NEW YORK

Another Big Bang

Yaël Nazé's article, "The priest, the universe, and the Big Bang" (November 2007), about George Lemaître's contributions to cosmology reminded me of a similar clerical connection to the Big Bang theory. An article in the June 2001 *History Today* cited an English church scholar, Robert Grosseteste (c. 1168–1253), who envisioned creation as "a sizeless point of matter whose form was light."

The sizeless point exploded and "instantly stretched the matter to the dimensions of the cosmos." Who knows what other prescient wisdom lies buried in clay tablets and parchments the world over? **— JULIUS WROBLEWSKI,** VANCOUVER, BRITISH COLUMBIA

Error resolved

The news article by Daniel Pendick on page 26 of November's *Astronomy* cites an effective aperture, or light-gathering area, of 820 feet (250 meters) for the CHARA interferometer's six 1-meter telescopes. The resolution of the six telescopes operating as an interferometer would indeed be impressive, but the light-gathering power of six 1-meter telescopes doesn't approach 820 feet. **— HAROLD CORNELIUS,** ARLINGTON, VIRGINIA

You are absolutely correct. The CHARA interferometer has the effective resolution, but not the aperture, of a telescope with an 820-foot diameter light-gathering surface. **— DANIEL PENDICK,** ASSOCIATE EDITOR

For the love of it all

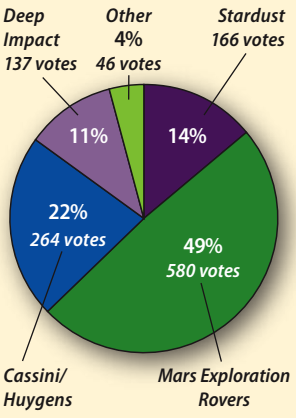
I really appreciated Bob Berman's recent column, "Hall of mirrors" (November 2007). Bob highlights the primary issues that should really be on the top of the list for today's "intelligentsia." He makes valid points in a lighthearted manner and yet they are probably the most important things that a civilized and educated society should be considering. **— WALTER DUTCHAK,** ST. THOMAS, ONTARIO

We welcome your comments. Send letters to Astronomy *Letters, P. O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.*

Webtalk

Online poll results

Which was the most impressive space mission in the past 5 years?



Total votes: 1,193

Join the fun! You'll find the weekly question on the lower right side of the home page.

WILLIAM K. HARTMANN/UCLA

DAWN launched in 2007.

Tune us in

Listen to our weekly podcast online or download it for later. Shows range from scientific breakthroughs to constellation tours to book reviews, and more.

DAWN ON ITS WAY

Principal Investigator Chris Russell provides an update on the Dawn mission to the asteroids Ceres and Vesta.

TOURING AURIGA

Senior Editor Michael E. Bakich explores deep-sky gems in the constellation Auriga.

GLOBAL-RENT-A-SCOPE

Arnie Rosner explains how you can shoot the sky using his service, Global-Rent-A-Scope.

Astronomy.com has everybody's favorites

Astronomy.com got a makeover, but you'll still find many of your old favorites. "Picture of the day" still serves up stunning images, and we've added new desktop wallpapers. Plus, now exclusively online, "Coming events" lists star parties, lectures, and workshops in your area; you can also add your events to our calendar.

Subscribers get MORE online

Magazine subscribers can enjoy **premium content** on Astronomy.com by logging in on the upper right side of the home page. Your subscription includes many online benefits, including access to:

- **Archive of Ask Astro questions and answers**
- **StarDome PLUS advanced sky software**
- **Annual index of *Astronomy* articles**

It's showtime!

Our exclusive videos share how-to tips, explain science headlines, showcase equipment, and more.

Featured video

HOW TO OBSERVE NEBULAE

Astronomy Editor David J. Eicher gives tips for teasing out faint details in these celestial clouds of gas and dust.

February web extras

Go beyond the stories printed in this issue with these subscriber-only features. Monthly web extras bring you additional research, interviews, photographs, and animations that our editors turned up while creating the magazine stories.

"How comets shaped history"

p. 22 PDF: See how 26 great comets stack up.

TONY AND DAPHNE HALLAS

Comet Hale-Bopp

"Journey to the center of the Milky Way" p. 28

Podcast: Astronomer Brad Hansen explains why he believes a second black hole lies at our galaxy's core.

"Where has all the water gone?" p. 52

View a gallery of MRO's latest images of the Red Planet.

"Observe winter's forgotten star clusters" p. 60

Explore 10 more little-known gems.

Glenn Chaple's "Surf the skies"

p. 68 *Astronomy* editors share their favorite web sites.

Phil Harrington's "Meet the colorful Gemini twins" p. 70

Use binoculars to observe the Eskimo Nebula and other deep-sky treats in Gemini.

This month's top blogs

Editors put their spin on current events in the staff blog. You can share your opinions on news headlines and popular culture, too.

1 **WOMEN IN SPACE.** Is media coverage harmful or helpful to women? **BY DANIEL PENDICK**

NASA/JSC

Astronaut Pamela A. Melroy

2 **USE YOUR SCOPE (ALMOST) FOREVER.** Dust is a telescope's worst enemy. **BY MICHAEL E. BAKICH**

3 **TOURING THE MOON ON DVD.** My only regret is that I didn't get to watch *Magnificent Desolation — Walking on the Moon* on the big screen. **BY JEREMY McGOVERN**

BY BOB BERMAN

Other dimensions

It's a sci-fi staple: A nerdy scientist

discovers how to transport himself to another dimension. There he meets creatures who look surprisingly human, but without any sense of humor. Except for blurry walls, it all resembles a dental office. You can't blame the film's special-effects department. How can anyone portray a different dimension? And yet, it's likely they really exist.

To qualify as another dimension, a realm must be totally inaccessible, like public bathrooms in New York City. Good examples include the "possibility branches" of quantum theory's Many Worlds Interpretation. According to the MWI, every experiment with more than one possible outcome — and every choice made in life — results in all possible things happening.

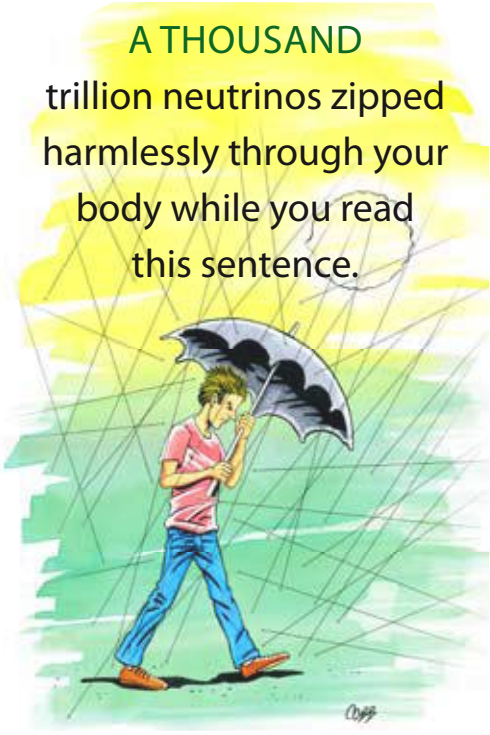
You're only aware of the world that contains the outcome you experience. But other worlds in which all the other possibilities came to pass are out there somewhere. Steven Hawking believes this, but I don't — even if some of those other "me's" feel differently. So let's move on.

Time dimensions. Einstein showed us that while we experience a single second, a million years can pass on another world if it has an enormous gravitational field or moves at great speed. Trillions of planets in high-redshift galaxies have huge relative velocities, so the table is already set.

During the same 2 minutes in which we grab a station-break snack when watching *The Office*, millions of years pass on those worlds. On a planet like ours, mountains would erode and a dozen ice ages come and go — all while we're munching on a chicken wing. Such parallel time dimensions are definitely real.

Invisible things. A thousand trillion neutrinos zipped harmlessly through your body while you read this sentence. You don't notice them, except when one hits a proton in your brain and makes you do something weird like vacuum the carpet.

A THOUSAND trillion neutrinos zipped harmlessly through your body while you read this sentence.



Dark-matter dimensions. Neutralinos may be the long-sought-after dark matter. If so, these tiny but massive subatomic particles might form larger, complex structures — maybe even dark-matter life-forms. Because they don't possess electrons and therefore can't create photons, they're invisible. Dark matter does exist right here in our galaxy, and probably even in our own rooms, as a separate unseen dimension.

Itsy-bitsy places. These days, invisible dimensions are routine office-cooler gossip for researchers pursuing string theory, which works only if you first invent at least seven extra dimensions. There's no evidence for any of them. If real, they would almost certainly exist only at the microscopic level, 10 billion times smaller than an atom. The almost-completed Linear Hadron Collider in Geneva might be able to detect their effects at the physical level.

Picturing it. Our own dimension can be inferred when we watch shadows. The shadow of a coin spinning on its edge might grow from a line to a disk and back again, and being inhabitants of a 3-D world, we can figure out which solid 3-D shape must be responsible. But if we were 2-D creatures forever confined to a flat world, we'd be unable to visualize the object responsible for those weird effects.

We are prisoners of our background and experience. Like a person born blind trying to imagine the color magenta, we cannot picture even one dimension beyond the familiar three or (if you include time) four. There's nothing wrong with your mind: Nobody can visualize other dimensions.

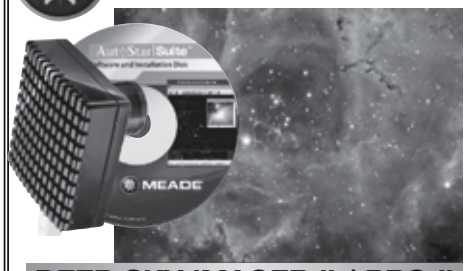
Scale dimensions. Many aspects of the subatomic world, although described accurately (if probabilistically) by quantum theory, cannot be represented by images or symbolized by logic. The same may be true in any supra-scale dimensions. It's an old idea: Our entire universe is a quark in a bit of soot being blown out a truck tailpipe of some enormously larger realm. Perhaps that entire universe, too, is just one module in a still bigger reality.

This sort of thing has always appealed a great deal to Russian cosmologists. They postulate continuous breakaway "Big Bangs" that create numberless parallel universes, connected to ours by impossibly thin one-dimensional threads.

Even with all that, our own dimension remains unique. Where else can you get a decent burger?

THE ULTIMATE IN ASTRONOMY SHOPPING:
www.adorama.com

MEADE



DEEP SKY IMAGER II / PRO II

Deep Sky Imager II (CLR)	$599.00
CCD Color Filter Set	$199.00
Deep Sky Imager Pro II	$599.00
Deep Sky Imager Pro II w/RGB	$699.00

- Dramatically lower noise
- Larger (1/2" chip)
- 74% Higher resolution (752x582)
- Greater sensitivity
- Temperature sensor

ETX PREMIER EDITION

Automatic Alignment + SmartFinder

Meade's new ETX-Premier Edition automatically levels your telescope, points it to North and sets the time.
You just enter your location or zip code. After your ETX completes its patented Level North automatic alignment procedure it will point to the first alignment star. Use the new wide-field SmartFinder to center the red dot over the alignment stars for ultra-precise pointing accuracy. It's that easy.

KEY FEATURES
- Electronic Level Sensor
- Electronic Magnetic North Sensor
- High Precision Internal Clock
- Red Dot Viewfinder (SmartFinder™)

ETX PREMIER	Price
90 PE w/UHTC	$699.00
125 w/UHTC	$999.00

New Lower PRICES

LEVEL NORTH™ TECHNOLOGY

SBIG ASTRONOMICAL INSTRUMENTS

•ST-402ME •ST-200XC •ST-7XME

Check Our Web Site for a Full Listing

COME SEE OUR NEW ASTRONOMY SHOW ROOM ON THE 5TH FLOOR

LX90 GPS SERIES

The Meade 8, 10, & 12" LX90
Includes with MgF2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally).

Camera Adaptable

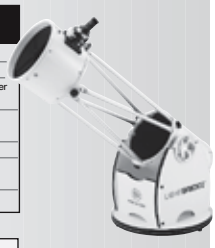
KEY FEATURES
- GPS & Level North Technology
- Smart Drive, Autostar Controller
- Oversize Primary Mirror, Diffraction - Limited Optics
- Rigid Cast Aluminum Fork Mount
- LX-200 Series Tripods
- Smart Finder (Red Dot) & 8x50 View Finder
- AutoStar Suite Astronomer's Edition Software

LEVEL NORTH™ TECHNOLOGY

LX90	Price
8" w/UHTC	$1,999.00
10" w/UHTC	$2,699.00
12" w/UHTC	$3,299.00

LIGHTBRIDGE DOBSONIANS

KEY FEATURES
FEATURES DELUXE
- Diffraction Limited Optics
- Meade Optical Coatings
- 2" Crayford-Style machined aluminum focuser w/1.25" adapter
- Advanced Red-Dot Finder (includes four reticles)
- Steel RA roller bearings
- 26mm QX™ Wide Angle 2" Eyepiece (70° field-of-view)
- Built-in Primary Mirror Cooling Fan



DELUXE	PRICE
8"	$599.00
10"	$799.00
12"	$999.00
16"	$1,999.00

ACCESSORIES	
1.25" Laser Collimator	69.95
Light Shroud for 8"	35.00
Light Shroud for 10"	40.00
Light Shroud for 12	45.00

STAR-BOUND

THE PERFECT CHAIR FOR ASTRONOMY VIEWING COMFORT

ADJUSTABLE FROM 9"-32", FOLDS FLAT, POWDER COATED WHITE OR BLACK

$159.00

ASTRONOMY BINOCULARS

Great for viewing The Heavens

Nikon PENTAX FUJINON Canon MEADE

We Stock The Complete Line

WE ALSO STOCK THESE OTHER FINE LINES

Thousand Oaks Optical · TELRAD · Starry Night · STAR-BOUND · PARALLAX · Leica · WILLIAM OPTICS · LUMICON · Vixen · RIGEL SYSTEMS · ZEISS · SWAROVSKI OPTIK · SOFTWARE BISQUE · KENDRICK ASTRO INSTRUMENTS · KNIGHTWARE

TAKAHASHI

FS-60, Sky-90, New Q, TOA-130, LE Eyepieces, **IN STOCK!**

Check Our Web Site For Details www.adorama.com

CORONADO

PST, SolarMax 40 Telescopes, 60 & 90mm systems

Check Our Web Site for a Full Listing

Tele Vue®

Adorama's 20th Year Proudly Selling Tele Vue

RADIAN EYEPIECES
60° FIELD
20mm Eye-Relief

PLOSSL EYEPIECES
Modest Price With Extraordinary Performance!

NAGLER EYEPIECES
82° FIELD
"SPACE WALK" VIEWING

PANOPTIC EYEPIECES
TACK SHARP 68° FIELD

BANDMATE FILTERS

DIOPTRX™
EYE SIGHT
Astigmatism correctors

Vixen Optics

VMC-110L 110mm Modified Cassegrain f/9.4 OTA Telescope with Skypod Altazimuth "Go To" Mount, & Aluminum Tripod AL

- Reflector, Modified Cassegrain
- Objective Diameter: 110mm
- Focal Length: 1035mm F/9.4
- Eyepiece PLössl 25mm (41X)
- 22,000 object database

R130SF 130mm
f/5.0 Newtonian Telescope
Multi-Coated Optical Tube
w/Accessories & Porta Mount

- Reflector, Newtonian
- Objective diameter: 130mm
- Focal Length: 650mm F/5
- Eyepiece: PLössl 20mm (33X) and 6.3mm (103X)
- Finder Scope: 6x30
- Porta Mount

SHIPPING INSTRUCTIONS See Our Web Site WWW.ADORAMA.COM For Shipping Charges And Relevant Information.

ADORAMA INC.
Source for the **Educated Photographer**

42 West 18th Street New York, N.Y. 10011 info@adorama.com
www.adorama.com • Order Toll Free USA / Canada **800-223-2500**
Orders & Information - **212-741-0052**

BY STEPHEN JAMES O'MEARA

Orion's phantom loop, part 1

You better sit down for this one. On the next clear and transparent night, go to the darkest site you know, lie down on a blanket or lounge chair, and make yourself comfortable. ☾ Use your unaided eyes to look for the emission nebula Sharpless 2–276 in Orion. Commonly known as Barnard's Loop, this bank of ghostly light forms a 10°-wide semicircle predominantly around the eastern side of Orion's belt and sword.

In wide-field photographs, especially in long exposures taken in red light, the Loop looks like the wing of a celestial snow angel made with Orion's right arm and leg. To the unaided eye, however, the Loop has about as much visual punch as a snowflake clinging to a frosty window. Seeing it (sans filter) is truly one of the greatest naked-eye challenges and the subject of many heated debates on cold winter nights.

Seeing ghosts

One such debate between Ohio amateurs Philip Hoyle and Phillip Creed inspired this column. In March 2005, while observing from an altitude of 3,000 feet (915 meters) in the Persimmon Gap section of Big Bend National Park in southwestern Texas, Hoyle saw what appeared to be Barnard's Loop. Creed then saw it, too. "I thought it might have been a chance alignment of stars," Creed said, but he confirmed its position on a star atlas and agreed with Hoyle that it could be nothing else.

"Barnard's Loop looked like a skinny, faint arc just east of Mintaka and straight south of Betelgeuse," Creed recalled. He noticed it was "brightest on the northern half," and said it looked almost like a "departed ghost" of the Milky Way.

"The strangest part was how easy it was to see," Hoyle said. "It looked like a finger of the Milky Way, but, as I recall, it didn't look really that skinny. It was just west of the Milky Way and just east of the classic figure of Orion, spanning from nearly shoulder to foot."

But is such an observation possible, they wondered?

No fooling

Yes, sections of Barnard's Loop are visible to the unaided eye. But, as Creed suspected, the eye can also be fooled by Orion's False Loop, which is why it's important to have a star atlas or photograph nearby. The False Loop is a 10°-wide semicircle of light that follows a coincidental curve of nine 4.5- to 5th-magnitude suns.

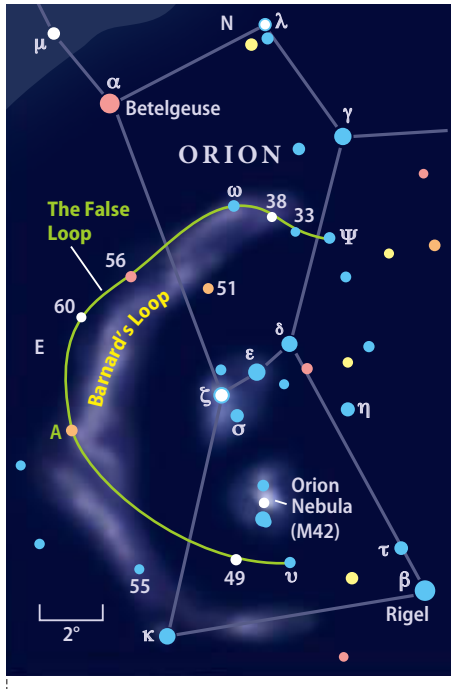
The northwestern portion lies about 4° north of Delta (δ) Orionis (Mintaka), the westernmost star in Orion's belt. It consists of Psi (Ψ), 33, 38, and Omega (ω) Orionis.

The eastern segment, nearly 5° northeast of Zeta (ζ) Orionis — the easternmost star in Orion's Belt — includes 56 and 60 Orionis and the star I've marked "A," located almost 3½° south of 60 Orionis.

The bottom segment of the false loop contains 49 and Upsilon (υ) Orionis, just south of the sword.

These dim stars appear as a fuzzy beaded necklace when observed with averted vision. That's because our eye-brain system, especially when working at low light levels, fills in the gaps to create a meaningful image.

Commonly known as the "etcetera principle," this connect-the-dots phenomenon occurs when the eye-brain system assumes a connection between individual data sets — in this case several arcs of stars. It is what led late American astronomer Percival Lowell to see strings of individual albedo features on Mars as linear "canals." It's also



THE EMISSION NEBULA Sharpless 2–276, often called Barnard's Loop, forms a ghostly glowing arc at the eastern side of Orion's belt and sword. The Loop is difficult for most people to see with unaided eyes. The brain may combine several dimly visible portions of Barnard's Loop into a continuous arc — the False Loop (colored line). *ASTRONOMY:* ROEN KELLY

why you can make a portrait of Elvis with 35 pieces of toast (no fooling!).

Working the eye

To see Barnard's Loop, you have to be patient and judicious. You'll also need to know how to position your eyes to maximize your averted vision. Peripheral vision serves as a motion detector. Because much of what we see is stationary, our eyes constantly jiggle to set things in motion. As a stationary object sweeps across the retina, receptors fire away, and we become aware of the object's presence.

To see an astronomical object as vast as Barnard's Loop, you need to sweep your eyes gently back and forth across a 10° field. But you should also align your eyes so the Loop's sections move over each eye's "hot spot" — the region at the retina's periphery most sensitive to faint light.

For instance, when I want to inspect a dim object at night, I direct my gaze toward the 4 o'clock position in the field of view. This places the object of interest in my hot spot, which lies in the upper left of the field. (The position of your hot spot might differ from mine.)

That's why I suggest you lie down. Orion stands high above the southern horizon during February evenings after sunset, which means the long axis of Barnard's Loop slices vertically across your retina. To maximize your chance of seeing the Loop, orient your body so the Loop's major axis is horizontal to your line of sight. This means positioning Orion on its side.

With Orion oriented this way, you can tackle seeing the Loop in pieces. Start with its brightest segment — a 5°-long arc of diffuse light that starts about 1° south of 56 Orionis and ends about ½° west of star A. Then direct your gaze toward Omega and 33 Orionis, but concentrate on the region of sky between 56 and 51 Orionis.

Slowly sweep your eyes toward Zeta (ζ) Orionis, but look for the Loop extending toward star A. Sweep southward, but redirect your gaze to a point above Orion's sword but concentrate on the region between A and 55 Orionis, and so on.

A hyperfine Loop segment lies midway between Kappa (κ) Orionis and Beta (β) Orionis (Rigel). Seeing it requires patience and rhythmic breathing (and, perhaps, the advantage of clearer skies at higher altitude). It also helps to extend your fingers to block the bright stars Kappa and Beta Orionis. The greatest challenge will be to see any glow between Omega and Psi Orionis; the nebula follows the string of dim stars between them, and it's hard to tell if the etcetera principle is at work.

If you succeed, then you have glimpsed what could arguably be the remains of an ancient supernova explosion or more than one supernova — the only such feature visible to the unaided eye. Let me know what you see: someara@interpac.net.

IN THIS TIME-EXPOSURE IMAGE, the emission nebula Sharpless 2–276 is barely detectable as a diffuse red glow east (left) of the line of bright stars forming Orion's belt. The wispy patch of light below the belt is the Orion nebula (M42). TONY AND DAPHNE HALLAS

Tough twins The Mars Exploration Rovers, Spirit and Opportunity, emerged September 7 from a 2-month dust storm healthy and ready to continue their missions.

For the latest news on space discoveries, spacecraft missions, and sky events, visit **Astronomy.com/news**

Astronews

NASA/ESA/HUBBLE HERITAGE (STScI/AURA)

MILKY-WAY MEGACLUSTER. A riot of young stars gleams in NGC 3603, one of the Milky Way's grandest star-forming regions.

18 New spin on Moon's birth

19 Youthful galaxy grows up

20 Black hole sets a record

21 Sharpest snapshots ever of Pluto's tiny moons

Hubble peers into a Milky Way starburst

One of the galaxy's most massive and luminous star clusters, NGC 3603, remains swaddled in its natal gas cloud. A new Hubble Space Telescope image released October 2, 2007, shows the region in breathtaking detail.

Ultraviolet light from the central cluster's hot, young stars sets nearby hydrogen gas aglow. Radiation and stellar outflows sculpt the gas into arcs, ribbons, and festoons.

But there's more here than meets the eye. The massive, glowing nebula is the visible portion of a vast molecular cloud complex some 400,000 times the Sun's mass.

Thousands of the central cluster's stars outweigh our Sun. In less than a cubic light-year, astronomers find a wide variety of hot, massive suns: three Wolf-Rayet stars, six O3 stars, and many O- and B-types.

Thanks to these outsized newborns, NGC 3603's central cluster is about 100 times more luminous than the Trapezium stars that power the famous Orion Nebula.

Astronomers think the cluster formed some 2 million years ago in a single burst of star formation. In fact, researchers see NGC 3603 as a local example of the kinds of young, massive clusters found in so-called starburst galaxies (see "Stellar archaeology," May 2005).

NGC 3603 lies about 20,000 light-years away in the Milky Way's Carina spiral arm.

— FRANCIS REDDY

NASA

SPARK GAP. Riding the shuttle's combined robot arm and extension boom, astronaut Scott Parazynski fixed ISS' electrically active solar panels. If touched, the panels could have delivered a lethal shock.

Harmony arrives at space station

On October 26, 2007, astronauts aboard space shuttle Discovery installed a new module on the International Space Station (ISS). Named Harmony, the new addition paves the way for later installations of European and Japanese laboratories, which will attach to it. The Italian-built module provides the first increase in ISS living space in 6 years. Delivering Harmony was the STS-120 shuttle mission's main goal.

The ship blasted off October 23 from Kennedy Space Center in Cape Canaveral, Florida. But because the shuttle had to dock with the port meant to host the new module, astronauts attached Harmony to a temporary location.

"It's kind of a shell game," Lead Shuttle Flight Director Rick LaBrode said. The station crew moved the module to its correct location after the shuttle departed.

NASA changed the activities of a planned fourth spacewalk so the crew could repair a torn solar array on ISS' Port 6 truss. Without the array, ISS couldn't generate enough power for the new European and Japanese modules.

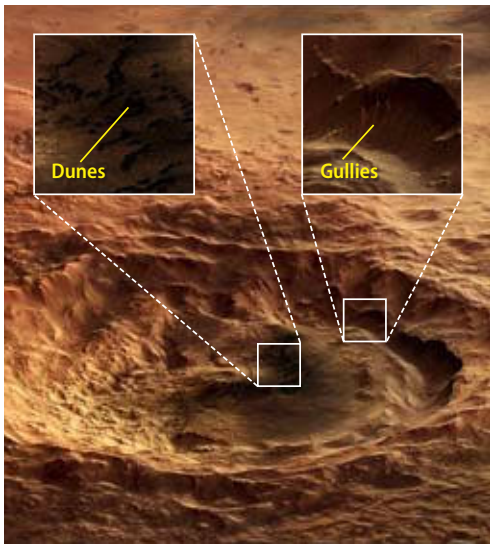
On November 3, astronaut Scott E. Parazynski cut a snagged wire that caused the tear. He also installed homemade stabilizers to strengthen the panel. Ground controllers were then able to fully deploy the panel. — **F. R.**

Mars Express sees martian "landfill"

Striking new images of Mars' Maunder Crater reveal sand dunes, gullies, and debris — telltale signs of a massive landslide. The European Space Agency released the image from its Mars Express spacecraft October 17, 2007.

Located in Noachis Terra, between the giant Argyre and Hellas impact basins, Maunder Crater is 56 miles (90 kilometers) wide but barely half a mile (0.9 km) deep. A landslide on the crater's eastern slope has sent dark material across the crater floor, filling in much of it.

Gullies on the crater's exposed walls may indicate areas with water seepage. Small, dark, arc-shaped features up to 1.6 miles (2.5 km) long occur in the crater's center. These are barchan sand dunes, a type common to deserts on Earth. — **F. R.**



ESA/DLR/FU BERLIN (G. NEUKUM)

SLIP 'N SLIDE. Maunder Crater's collapsed eastern wall (right) fills much of the structure.

QUICK TAKES

TRIAL BALLOON
On October 3, U.S. engineers tested the balloon that will loft the world's largest Sun-observing UV telescope to 120,000 feet in 2009.

COME CLOSER
Astronomers remeasured the distance to the Orion Nebula (M42). It's 1,270 light-years away, 19-percent closer than the previous estimate.

TAIL SNATCHER
A solar storm ripped Comet Encke's tail off April 20, 2007. NASA's twin STEREO satellites recorded video and still images of the event.

HOLD ON TIGHT
MIT scientists proposed a tether system to keep astronauts from drifting into space as they explore low-gravity asteroids.

HITCHHIKERS TO MARS
NASA will fly two Russian experiments on the Lunar Reconnaissance Orbiter (2008) and the Mars Science Laboratory (2009) missions.

SMALLER HOLE
In October 2007, Europe's Envisat satellite found Antarctic ozone depletion is 30-percent less severe than in the previous year.

SAT DOWN
One of two Double Star satellites, the China National Space Administration's first science missions, fell to Earth on October 14.

CHINA STRIKES GOLD
China issued 2,007 sets of two 25-gram gold bars October 25, 2007, to commemorate the launch of its Chang'e-1 lunar probe.

LOW FUEL
Engineers found a way to redistribute thruster fuel on two aging communications satellites, extending their lives for 6 months.

WIDE EYE
On July 31, the European Very Large Telescope in Chile opened a new eye: a wide-angle, near-infrared camera to study distant stars, galaxies, and gaseous exoplanets.

SEEKER
Hidden within our solar system are infinite stories just waiting for you. Embark with Seeker™ on a captivating exploration of stunning realism that will enrich and educate. With Seeker, there is no dark side of the moon.
seeker3d.com
From Software Bisque – Seeker $129.00
Seeker copyright 2007 Software Bisque, Inc. All rights reserved.
an immersive 3D solar system journey
bisque.com
Universal
Mac
Windows Vista
Windows XP

New spin on Moon's birth

EARTH SCIENCES AND IMAGE ANALYSIS LABORATORY/NASA JOHNSON SPACE CENTER

BACKSPIN. Computer simulations of the impact that formed the Moon produce better results when the early Earth spins backward.

Planetary scientists generally agree the Moon formed when a Mars-sized object slammed into the young Earth. Now, new simulations of the event include Earth's spin in the calculations, improving on past results.

To simplify the physics of previous computer simulations, researchers excluded rotation from both Earth and the impactor. Robin M. Canup of the Southwest Research Institute in Boulder, Colorado, took the next step by including rotation. Then she ran simulations of the impact featuring a range of speeds, masses, and angles.

Including rotation didn't drastically change the Earth-Moon collision's outcome. However, Canup found the best results occurred in impacts where the proto-Earth spun opposite the way it does now.

The new simulations improve on previous studies, which always left the final Earth-Moon system with at least 20-percent more angular momentum than astronomers actually measure.

Canup presented her findings October 10, 2007, at the American Astronomical Society's Division for Planetary Sciences meeting in Orlando. — **RICHARD TALCOTT**

25 years ago in *Astronomy*

February 1983

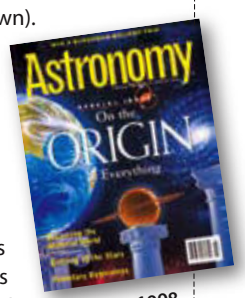
The February 1983 cover feature, "Vesta: A world of its own," reviewed astronomers' then-limited knowledge of the giant asteroid. Author William Hartmann outlined the 1807 discovery of Vesta and introduced readers to the techniques astronomers employ to find and observe asteroids.

In 1983, skygazers knew the asteroid as a mere dot. Hartmann, an accomplished space artist, painted Vesta as a cratered, Moon-like world. In 1995, the Hubble Space Telescope provided the first photographic view. NASA's Dawn spacecraft will best Hubble's efforts when it reaches Vesta in 2011.

Launched in September 2007, Dawn is headed to the asteroid belt to study Vesta and another minor planet, Ceres. By examining these protoplanets, scientists hope to uncover clues about planet evolution and the conditions of our early solar system.

You can listen to Dawn's head scientist, UCLA's Christopher T. Russell, as he discusses the upcoming visit to Vesta and Ceres in *Astronomy*'s October 25, 2007, podcast (www.Astronomy.com/Dawn).

10 years ago in *Astronomy*

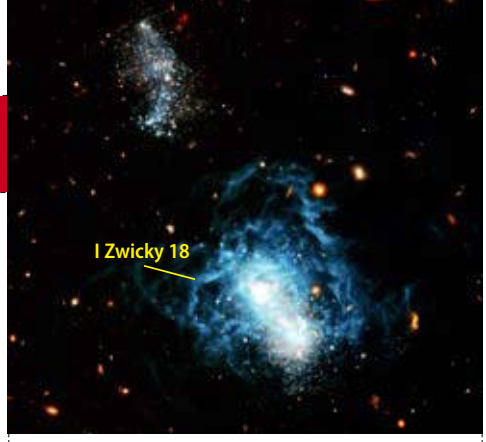


February 1998

In February 1998, *Astronomy* and its now-defunct sister publication, *Earth*, released a two-part special report devoted to the origin of everything. In "Planting primordial seeds," Edward "Rocky" Kolb of the University of Chicago tackled the Big Bang.

As Kolb explained, the Big Bang ejected matter haphazardly, generating a primordial soup of energy and subatomic particles. Galaxies and the other structures we see today may have begun as minute quantum fluctuations in the early universe.

In 1937, Danish physicist Niels Bohr tried to understand how the laws of quantum mechanics operate on fundamental particles. Thanks to Bohr's pioneering work, we are closer today to understanding how the microworld shapes the cosmos. — **JEREMY McGOVERN**



NASA/ESA/ALESSANDRA ALOISI (ESA/STScI)

AGING GRACEFULLY. **Hubble observations reveal dwarf galaxy I Zwicky 18 and a smaller companion galaxy (upper left).**

Youthful galaxy grows up

New Hubble Space Telescope observations have forced the dwarf galaxy I Zwicky 18 to grow up in a hurry. The latest findings say the galaxy is far older than astronomers thought.

I Zwicky 18 is among 30,000 nearby galaxies Swiss astronomer Fritz Zwicky cataloged in the 1930s. Observations 40 years ago at Palomar Mountain Observatory in California first suggested the galaxy's stars sparked to life as recently as 500 million years ago.

Later studies found the same result. Yet, strangely, I Zwicky 18 lies in the local universe, where the Milky Way and neighboring galaxies are typically 12 billion years old. The situation seemed as incongruous as a maternity ward in a retirement community.

Using the Hubble Space Telescope, a team led by Alessandra Aloisi of the European Space Agency and Space Telescope Science Institute discovered faint, older red stars in I Zwicky 18. Their presence indicates star formation in the dwarf started 10 billion years ago, similar to other local galaxies. The team published its findings October 1 in *Astrophysical Journal Letters.*

Aloisi's team also determined a more accurate distance measurement for I Zwicky 18. By using special distance-marker stars called Cepheid variables as reference points, the scientists calculated the galaxy lies 59 million light-years from Earth. This distance exceeds the previous estimate by nearly 10 million light-years. — **DANIEL PENDICK**

Built for Astronomers by Astronomers

For over 20 years, astronomers worldwide have relied on one constant –TheSky6 Astronomy Software. While others have come and gone, innovations in TheSky6 continue to enrich your astronomy experience.

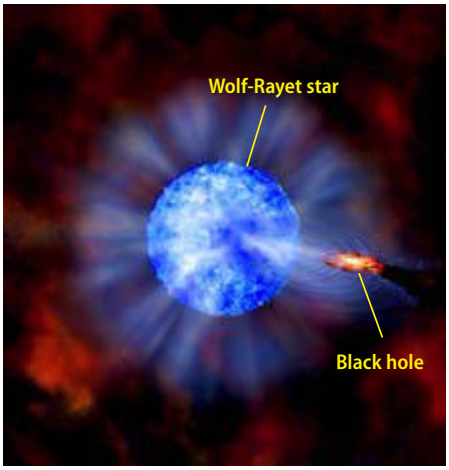
Ground breaking innovations, such as encoder-based telescope control, integrated CCD camera and telescope control, ingenious algorithms that aid in identification of celestial objects in CCD images, integrated access to the Digitized Sky Survey, and automation technology that operates robust observatories – are but a few.

Innovations that you count on, all from one source. TheSky6 Astronomy Software – the one constant that does it for you.

bisque.com

THESKY SIX
ASTRONOMY SOFTWARE

Astronomy's engine



NASA/CXC/M. WEISS

STELLAR HEAVYWEIGHTS. **A giant black hole orbits its companion in galaxy IC 10.**

Black hole sets a record

A binary star system in the irregular galaxy IC 10 hosts the most massive stellar black hole yet known — at least 23 times more massive than the Sun. "Black holes from dying stars can be much larger than we had realized," says Andrea Prestwich of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts.

Prestwich led the team of astronomers that gauged the black hole's mass. They reported their findings in the November 1 *Astrophysical Journal Letters.*

Dubbed IC 10 X-1, the black hole orbits a Wolf-Rayet star that eclipses it every 34.4 hours. The binary's eclipsing behavior allowed Prestwich's team to determine a range of masses for both objects. The astronomers believe the black hole weighs between 23 and 35 solar-masses. Its companion holds from 17 to 35 solar-masses.

The black hole's great mass is difficult to reconcile with conventional models of how massive stars evolve. Astronomers think stars shed much of their bulk through stellar winds before they die. However, stars with lower metal content, such as those found in IC 10, tend to have weaker winds.

The astronomers studied the black hole with data from NASA's Chandra X-ray Observatory and Swift satellites and the Gemini North Telescope in Hawaii. **— F. R.**

North Korea's phantom space program

If there's one place in the world guaranteed to avoid nighttime light pollution and thus offer ideal conditions for sky watching, it's got to be North Korea. From orbit, the nation stands out from neighboring China, South Korea, Russia, and Japan as a virtual "black hole" of darkness with almost no visible artificial lighting.

So on August 31, 1998, when North Korea announced the launch of its first satellite, North Koreans could easily go outside at night and watch their country's technological achievement drift by in the sky. In rallies organized by the communist government, hundreds of thousands of North Koreans did exactly that.

North Korean officials said their Kwangmyongsong ("Bright Light Star") satellite was circling Earth in an elliptical orbit while performing scientific research. The satellite reportedly broadcast melodies of "immortal" revolutionary hymns such as "Song of General Kim Il Sung" and the "Song of General Kim Jong Il."

To top off the orbital offerings, the satellite purportedly transmitted Morse Code spelling out the motto "Juche Korea," or "Korean self reliance." But there wasn't any satellite, despite the enthusiastic oohs and aahs of sky-watching crowds.

The launch rocket, a modified military missile, seems to have fallen short of orbit and burned up over the North Pacific. Apparently, the scientists were afraid to tell ruling dictator Kim Jong Il about the failure. Instead, they announced the mission's success and counted on the obedient population to pretend they could actually see the satellite passing overhead.

A rerun of this "space charade" may be in the offing. North Korea may announce a major new breakthrough in its space program early this year — whether it actually occurs or not. The likely motivation, as with the bogus satellite, will be international status — or, more precisely, status on the Korean Peninsula.

North Korea is well aware that its neighbor, South Korea, has booked a flight into orbit for its own astronaut, aerospace engineer Ko San. Early April is the planned launch date for the Russian Soyuz mission that will carry San to the International Space Station for a 10-day mission. His country is already growing enthusiastic about the impending space triumph.

AP

READY FOR ORBIT. **South Korea chose Ko San, a 30-year-old aerospace worker, to hitch a ride on a Soyuz launch to the International Space Station in April.**

Most observers familiar with the mindset and methods of Kim Jong Il would not be surprised if the first Korean in space was, suddenly, a North Korean citizen. That country does have rockets powerful enough to throw a small capsule — perhaps equipped with an ejection seat modified from a jet fighter — into space on a brief ballistic lob. It could reach an altitude of 125 miles (200 kilometers) or more and splash down in the Sea of Japan.

Such a mission is within North Korea's technological capabilities. It would make sense for the country to try it. But if problems prevented the launch — or, worse, if problems prevented the astronaut's safe return — North Korean culture would require a backup plan. The "Kwangmyongsong solution" would be a stand-in pseudo-astronaut to present to the world. So if such a claim suddenly appears in the near future, experts will be looking at it closely before awarding any additional world-class "astronaut wings" to the claimants. **— JAMES OBERG**

BRIEFCASE

Now, that's odd!

Astronomers used NASA's Swift and Rossi X-ray Timing Explorer satellites to discover a bizarre stellar pair. The binary system consists of the core of a star orbiting a rapidly spinning neutron star (pulsar).

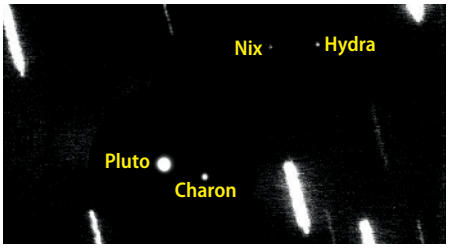
Apparently, the pulsar tore the outer layers off the star, leaving only a helium-rich core about 7 times the mass of Jupiter. The pulsar rotates once every 54.7 seconds, orbited by the stellar core at roughly the Earth-Moon distance. — **D. P.**

Double take

Asteroid observers were relieved to locate the potentially hazardous asteroid (PHA) 2007 RR_9, which could someday collide with Earth. The sighting solved another problem: Where, oh where, did minor planet 6344 P-L go? The PHA was last seen in 1960. Now, astronomer Peter Jenniskens of the SETI Institute has the answer: 6344 P-L and 2007 RR_9 are the same space rock. As a result, there's one less PHA to worry about (886, down from 887). — **D. P.**

Cosmic Google

The AEGIS sky survey released a set of space-telescope images and data using Google Sky, the astronomical viewing tool recently added to the Google Earth program. AEGIS joins 100 astronomers around the globe to observe the same small slice of the northern sky in X-ray, ultraviolet, infrared, and visible light. Project leaders hope Google Sky will make it easier for astronomers to collaborate with colleagues and explore the new data. — **D. P.**



DAVID THOLEN (UNIVERSITY OF ARIZONA)

FAMILY PHOTO. Artificially masking Pluto's glare rendered its three known moons visible in the same image.

Sharpest snapshots ever of Pluto's tiny moons

Astronomers used one of the 10-meter Keck Telescopes in Hawaii to snap the sharpest images to date of Pluto and its three known moons — Charon, Hydra, and Nix. David Tholen of the University of Hawaii observed the Pluto system for an hour and captured 16 separate images.

Keck's adaptive-optics technology canceled atmospheric distortions, enabling Tholen to clearly image Pluto's tiny satellites, Nix and Hydra. He then combined the 16 images into a single view.

The satellites, estimated to be less than 62 miles (100 km) in diameter, are exceedingly dim. Both shine at magnitude 23.5, in contrast to Pluto's magnitude 14 glow. Stars visible to the naked eye come in at about magnitude 6.5. This means Nix and Hydra are 6 million times dimmer than the faintest star visible to the naked eye.

Tholen's images are striking, but also useful. He and his team plan to image Pluto several more times, tracking the moons completely around the dwarf planet. By measuring slight shifts in the moons' orbits due to mutual gravitation, Tholen hopes to nail down better measurements of their masses and diameters. — **D. P.**

Best Home Weather Station!
VANTAGE PRO2™
MORE frequent weather updates—every 2½ seconds
MORE graphs—over 80 in all—for highs, lows, totals
MORE alarm settings—over 70 parameters
MORE history—every 24 hours, days, months or years
With Vantage Pro2 you get details on wind, rain, temp, barometric pressure, humidity, and your own local forecast. Go wireless and transmit up to 1,000' (over 3x the distance of competing station)!
Get WeatherLink® data logger and software for the ideal weather package! Cabled starts at $495.
Order now or ask for your FREE catalog.
800-678-3669
www.davisnet.com/astro
Davis Instruments
3465 Diablo Ave, Hayward, CA 94545
30-Day Money-Back Guarantee
Full 1-Year Warranty
AST0802

NOT ALL FOCUSERS ARE CREATED EQUAL!!
JMI's Focusers have more muscle than you will ever need to lift cameras and heavy equipment. No slipping with this 3-knob speed reducer.
EVENT HORIZON
EV-1n $300.00*
NGF-XT EXTREME $512.00*
Add Motor $140.00*
* Accessory (nontelescope) prices now include FREE shipping within the 48 states and DISCOUNTED shipping to all other locations.
JMI's NEW SPEED DIAL
Hook this drive to your electric drill and raise, lower and level your WHEELY BARS in a heart beat.
$34.00*
What's new at JMI
· MOTOFOCUS for the ETX 90, 105 and 125 $150.00*
· Piggy-back camera mount for the NexStar 8" SE $59.00*
JMI Telescopes - Jim's Mobile, Inc. - 8550 W 14th Ave - Lakewood, CO 80215 - U.S.A.
Info 303-233-5353 - Fax 303-233-5359 - Orders 800-247-0304 - info@jmitelescopes.com

COMET HALE-BOPP (C/1995 O1) was the most active comet in centuries. On March 7, 1997, the North America Nebula in Cygnus appeared framed between Hale-Bopp's blue gas tail and its brighter dust tail. TONY AND DAPHNE HALLAS

How comets shaped history

In ancient skies, a comet's sudden appearance provided both spectacle and portent — and savvy leaders took advantage. /// BY RICHARD JAKIEL

Great comets are one of nature's grandest sky spectacles. They usually appear unpredictably, move like nothing else in the night sky, sport complex tails spanning tens of degrees, and then fade into oblivion. "If there is a central theme that runs throughout the history of comets," writes NASA comet expert Donald K. Yeomans, "it must be the public concern they have commanded — concern completely disproportionate to their infrequent visits, subtle radiance, and modest sizes."

Not everyone was fooled. Seneca, a Roman writer of the first century, thought comets were heavenly bodies with orbits much like planets. And while many viewed these celestial visitors with a mixture of fear and wonder, some found ways to "spin" a comet's sudden appearance to their advantage. A comet could validate a new king, honor a fallen leader, or portend an enemy's demise.

Today, we know comets are essentially "dirty snowballs" — mixtures of dust and frozen gases orbiting the Sun. Comets' unusual motions through the sky stem from their elliptical orbits, which briefly take them through the inner solar system. As the Sun's warmth turns some ice to gas, dust-laden jets erupt and expel material. The Sun sweeps this matter behind comets to form their splendid tails.

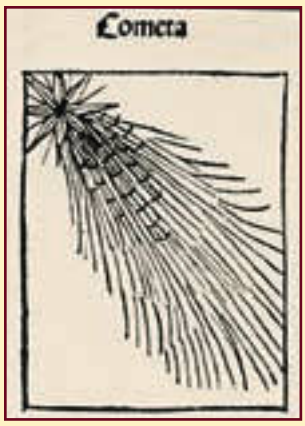
Greek philosopher Aristotle, writing in the fourth century B.C., described comets

WAS COMET McNAUGHT (C/2006 P1) a "horse comet"? The distinct banding in its broad dust tail fits a first-century A.D. description of a type of comet with a horse's mane. ESO/SEBASTIAN DEIRIES

COMET HYAKUTAKE (C/1996 B2) shines above Utah's Hellgate Cliffs March 26, 1996. Although Hyakutake was an intrinsically faint comet, it passed relatively close to Earth. CHRISTOPHER CLEMENS

/// HISTORY VIA HALLEY

Comet 1P/Halley is the brightest and best known of the short-period comets, those that circle the Sun in fewer than 200 years. Here are a few stops along Halley's journey through history.



◀ THE 1066 Halley's apparition was later viewed as a portent of doom for England's Harold II. The legend near the stylized comet reads: "They marvel at the star." Beneath the comet, an aide informs the king of the omen. FROM THE LIBRARY OF CONGRESS

◀ HALLEY'S 684 APPEARANCE inspired this woodcut, which was crafted in 1493. It appears in Hartmann Schedel's *Nuremburg Chronicles*. FROM THE LIBRARY OF CONGRESS

as being terrestrial in origin — a type of fiery display in the upper atmosphere. Pliny the Elder, a first-century Roman writer, portrayed comets as important astrological omens and classified these objects into 10 major types. Such views would dominate comet theory well into the 17th century.

Ephorus' Comet

Relatively few comets were bright enough to cause a stir in the ancient world.

A WOODCUT from the 17th century shows a variety of comet forms, including celestial sabers. FROM THE LIBRARY OF CONGRESS

Yeomans puts 59 comets into the "great" class, and the first of these appeared during the winter of 373/2 B.C.

Visible for many weeks, the comet's tail spanned a third of the way across the sky (60°). Aristotle witnessed it, and, in his book on meteorology, associated the comet with an earthquake and tsunami. More telling is the observation of Greek historian Ephorus of Cyme, who reported the comet split into two pieces.

Beginning in the 19th century, astronomers speculated Ephorus' comet was the granddaddy of a comet family characterized by extremely close passes to the Sun — the Kreutz sungrazers. This group includes some of the brightest comets in recorded history (see "Sungrazing comets," March 2006).

For a time, researchers thought this might indeed be possible. But Asian chronicles of the time make no mention of Ephorus' comet. And backtracking the largest known Kreutz member, C/1882 R1, brings it closest to the Sun (perihelion) in 315 B.C. — a difficult discrepancy to explain.

Mithradates' "Horse comet"

In the first century B.C., the Roman Republic controlled much of the Mediterranean world, and its interests were expanding eastward. But Mithradates VI, King of Pontus — in what is now central Turkey — proved to be a major roadblock. He led his armies against Rome in several wars before his 65 B.C. defeat.

Not one, but two comets are associated with this "scourge of Rome" — the first with his birth (134 B.C.) and the second with his coronation (119 B.C.). Both comets became symbols of Mithradates' greatness, but it's the first that most interests researchers like Rutgers University's Michael Molnar.

Mithradates struck some bronze coins that depict a foreboding *hippeus* (horse) comet. Pliny, the Roman naturalist, says this kind of comet had plumes like horses' manes. Molnar suggests the horses' manes are synchronic bands — dusty streamers in the tail that arc toward the comet's icy nucleus. These unusual features were a highlight of last year's appearance of Comet McNaught (C/2006 P1).

Molnar believes the visibility of these bands indicates *hippeus* comets had a close encounter with Earth, approaching perhaps as close as 600,000 miles (1 million kilometers). One ancient writer, Hephaistion of Thebes, says *hippeus* comets foretell the quick fall of kings and tyrants and rapid changes in national affairs. "It is likely that the comet was interpreted as an omen of violent revolution, but Mithradates apparently altered the focus of the portent," explains Molnar. How? Molnar thinks Mithradates transformed the comet into a symbol of his own struggle to evict Rome from Asia Minor.

Caesar's Comet

Arguably the most famous comet in antiquity is Julius Caesar's Comet. The ghostly visitor appeared during the months following the Roman dictator's March 15, 44 B.C, assassination. Chinese astronomers — then, the best in the world — recorded the comet reached a peak magnitude of –3.0 between May 18 and June 16.

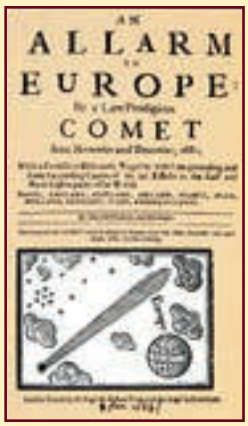
A comet this bright would have caused a major stir among Rome's populace —

— Continued on page 26

◀ HALLEY'S 1301 return inspired the Star of Bethlehem in Giotto di Bondoni's Nativity fresco in Scrovegni Chapel, Padua, Italy. ESA

▶ IN *COMETOGRAPHIA,* published in 1668, Johannes Hevelius sketched Comet Halley at its 1607 return (third from the top).

FROM THE LIBRARY OF CONGRESS



◀ WHILE MANY feared the comet of 1680, Edmond Halley managed to calculate its orbit — a first in cometary astronomy. He would later predict the return of the comet that bears his name.

COURTESY OF THE HOUGHTON LIBRARY, HARVARD COLLEGE LIBRARY, F*EC65.H5533.681A

RECIPE FOR A GREAT COMET

About once a decade, on average, a comet appears so visually impressive astronomers rate it as a "great comet." Here's how a comet qualifies:

Earth passage. Even modestly active comets like Hyakutake (1996) or 1P/Halley (1910) can put on great displays if they pass close enough to Earth.

Activity. When a comet nears the Sun, its icy surface vaporizes and frees up lots of gas and dust. This activity creates the enormous tails that make comets so striking. All comets undergo this sort of activity — some more, some less. But an unusually active one, like Hale-Bopp (1997), can put on a terrific show, even if it doesn't pass close to Earth or the Sun.

Sun passage. Because the Sun's heat activates a comet's icy surface, a close solar approach can make an otherwise humdrum comet shine brightly. The more dust a comet ejects, the brighter and more visually striking it can be.

A close pass by the Sun actually cracked the nuclei of comets Ikeya-Seki (1965) and West (1976) to pieces. This ejected large amounts of dust, which formed naked-eye tails more than 30° long.

Any one of these ingredients will serve up a great comet. — *Francis Reddy*

Comet McNaught
C/2006 P1

Discovered: August 7, 2006

Brightest: Magnitude (mag.) –6 on January 13, 2007

Closest to Sun: 15.9 million miles (25.5 million km), January 12, 2007

Closest to Earth: 75.9 million miles (122 million km), January 15, 2007

Comet Hyakutake
C/1996 B2

Discovered: January 20, 1996

Brightest: Mag. 1 on April 20, 1996

Closest to Sun: 21.4 million miles (34 million km), May 1, 1996

Closest to Earth: 9.3 million miles (15 million km), March 25, 1996

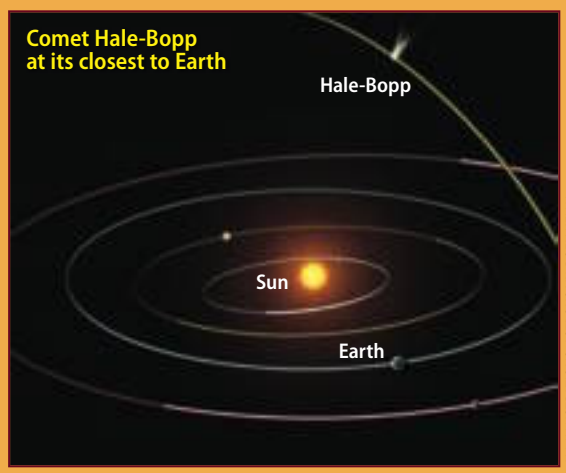
Comet Hale-Bopp
C/1995 O1

Discovered: July 23, 1995

Brightest: Mag. –0.7 on March 26, 1997

Closest to Sun: 84.6 million miles (136 million km), April 1, 1997

Closest to Earth: 122.7 million miles (197 million km), March 22, 1997



ALL ILLUSTRATIONS: *ASTRONOMY:* ROEN KELLY

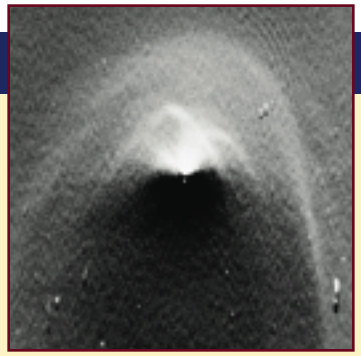
especially given its timing, following the death of a great leader. But historians find no reported observations of Caesar's Comet until July 23. Why is there a discrepancy of more than 1 month?

The answer can be found on the island of Sicily, several hundred miles to the south. Geologic evidence and anecdotal reports of the time suggest Mount Etna, a large volcano, underwent significant eruptions. The eruptions injected sulfur-rich aerosols into the upper atmosphere from just before Caesar's death, and they continued for months afterward. Roman sources reported the "Sun's light pallid and feeble

— Continued from page 25

Anzeige
vorhergekündigte Comet
einem Liebhaber der Sternwissenschaft.

◀ IN JANUARY 1759, the German *Hamburgisches Magazin* announced Johann Palitzsch's recovery of Halley's Comet. Edmond Halley's bold prediction had come true. FROM THE LIBRARY OF CONGRESS



▲ THIS IMAGE OF HALLEY, taken in May 1910 using the Mount Wilson 60-inch reflector, reveals complex structure around the comet's nucleus, which is too small to be seen directly. STEVE LARSON, LPL/UA

◀ THE "HALLEY'S COMET RAG" was one of many products of 1910's comet craze. FROM THE LIBRARY OF CONGRESS, MUSIC DIVISION

throughout that year." Local crop failures occurred in Rome, and China recorded widespread famine in 43 and 42 B.C.

By the time the eruptions subsided, the comet had dimmed considerably, which explains the lack of Roman sightings. In July, as the comet faded from view, Octavian (later known as Augustus Caesar) threw an Olympic-style event — Caesar's Funeral Games — in honor of his dead great-uncle.

As if on cue, the comet underwent a dramatic flare-up on the games' opening day. Classicist John T. Ramsey and physicist A. Lewis Licht, both at the University of Illinois in Chicago, say it surged nearly 10 magnitudes in brightness (10,000 times) and was visible in daylight low in the northeastern sky near Cassiopeia. Reports suggest the comet peaked near magnitude –8 but lacked the long, graceful tail it bore earlier in the apparition. They describe the comet as a reddish, almost starlike object with short rays. The brightness surge lasted only 1 week — the length of the games — before the comet rapidly faded from view.

Such an outburst isn't unusual, but one associated with an intrinsically bright comet — and timed so perfectly — is the stuff of legend. Octavian knew a good opportunity when he saw it. He declared the strange "star" to be Caesar's spirit ascending into the heavens.

Twenty-six years later, in 18 B.C., another bright comet graced Rome's skies. Augustus, then the emperor of Rome for the 13 years, proclaimed this was the return of Caesar's spirit. He commemorated the event with a series of *denarii*, dime-sized silver coins. On each coin's reverse was a fiery comet framed by the words *Divus Iulius* — the Divine Julius (Caesar). Decades later, Pliny the Elder lamented, "The only place in the whole world where a comet is the object of worship is a temple in Rome."

JULIUS CAESAR returned in cometary guise in 18 B.C. — at least that's how Emperor Augustus played the timely arrival of a bright comet. He commemorated the event on a series of coins. Inscribed on the reverse is *Divus Iulius*, "the Divine Julius," combined with a comet. F. P. VAN BOVEN PHOTO

Many Halley returns

1P/Halley, better known as Halley's Comet, is the brightest and most famous periodic comet. Halley returns every 76 years, on average. The first recorded sighting goes back to 240 B.C., which gives astronomers observational data for 30 apparitions.

Although Halley's lackluster appearance in 1986 underwhelmed observers, many of its appearances have been spectacular. In fact, Don Yeomans' great comets list contains no fewer than 22 Halley apparitions.

In the comet's March A.D. 837 close approach, when it passed just 3 million miles (4.5 million km) from Earth, Halley reached magnitude –3 and became nearly as bright as the planet Venus. Such appearances sometimes placed Comet Halley at history's center stage.

Agrippa's death. Marcus Vispanius Agrippa was Augustus Caesar's second in command and a trusted friend since boyhood. A skilled general and admiral, Agrippa's military prowess helped Augustus achieve victory over Marc Antony and secure the Roman Empire's foundation.

Agrippa also was a popular provincial governor and built many public works. When he fell ill and died in the spring of 12 B.C. after campaigning in the upper Danube province of Pannonia, Augustus and the people of Rome were shocked. To commemorate the death of his closest friend and ally, Augustus held elaborate funeral games.

While the games were in progress, an impressive comet (Halley) appeared in the evening sky. It brightened to magnitude 1.0 as it moved from Scorpius to Ursa Major. To Augustus, this must have seemed like *déjà vu*.

THE COVER of the April 16, 1910, *Scientific American* **included a map for finding Halley's Comet in the pre-dawn sky.** SCIENTIFIC AMERICAN

DARKER than coal, the nucleus of Comet Halley was first seen close-up in 1986, when the European Space Agency's Giotto probe flew past it. ESA/MAX PLANCK INSTITUTE FOR SOLAR SYSTEM RESEARCH

THESE COMETS come from a 2,200-year-old manuscript, part of the Mawangdui Silk Book recovered from a Chinese tomb. The book contains 29 drawings of comets, each of which is accompanied by the name of the comet and its astrological implications. These comets indicate "war for years." FROM *HALLEY'S COMET!* (1985)

Nero's "curse." Of all Rome's rulers, Nero, the last emperor of the Julio-Claudian line, seemed to have a particular affinity for comets. When his uncle Claudius was poisoned (A.D. 54), a bright comet sporting a 7°-long tail was visible for a month. A decade later, just before the great fire that destroyed much of Rome, another comet appeared in the evening sky. Usually, at these times, Nero's chief astrologer advised the emperor to "expiate the evil" through the execution of select senators — a duty he carried out with pleasure.

In A.D. 66, Halley became *a sword-like apparition—* a sign to *challenge Rome.*

But when Halley's Comet appeared before dawn February 20, A.D. 66, Nero's world was very different. The popularity he once had enjoyed was long gone. Rebellion was brewing in the province of Judea. In late March, Halley reached 1st magnitude and became a sword-like apparition some would take as a sign to challenge Rome.

By mid-summer, the first Jewish revolt was underway. Not long thereafter, Nero left on an extended tour of Greece and the eastern provinces to escape unrest in Rome. When several usurpers to Nero's power appeared, the emperor was on the run. Two years later, in A.D. 68, Nero committed suicide, and the Empire fell into civil war. Meanwhile, in Judea, the Roman army besieged Jerusalem, destroyed the city, and crushed the rebellion.

The Norman invasion. A millennium later, Halley would trouble King Harold II of England. His ascent to the throne following the death of Edward the Confessor was controversial; some thought the throne should have gone to William, duke of Normandy. So, when the comet appeared during the spring of 1066, it struck fear in Harold's heart.

Halley's 1066 apparition was extraordinary. By April 24, the brilliant comet had closed to 10 million miles (16 million km) from Earth and shone at nearly –2.0 magnitude. By April 26, the tail stretched at least 22° across the evening sky. Commoners, nobles, and Church authorities alike saw this "hairy star" as an evil omen.

As October opened, Harold's army destroyed an invading Viking force led by Norwegian King Harald Hardrada. Then, on October 14, following a forced march, Harold's army met Duke William of Normandy's forces near the town of Hastings. Despite having a larger army and a better defensive position, Harold was killed and the English army routed.

William — now called "the Conqueror" — commissioned the famous Bayeux Tapestry to commemorate his victory. On one panel of the 20-inch-by-230-foot-long (0.5 meter by 70m) tapestry, a small crowd points to the great comet. Halley's appearance "foretold" Harold's defeat. But to England's new ruler, the comet served as a symbol of heavenly affirmation.

Back to the future

It's enlightening — and even a little amusing — to see how our forebears reacted to and took political advantage of new comets. But there's one reason our laughter should ring a little hollow.

Spacecraft reveal that comets and asteroids have hammered every body in the solar system over the eons. Even on Earth, geologists know of more than 170 impact craters, some several hundred miles across.

In 1994, as if to underscore the reality of impact hazards, the fragmented comet Shoemaker-Levy 9 dramatically collided with Jupiter. Long-period comets like McNaught, with orbital periods longer than 200 years, will remain the wild cards of Earth impacts. Astronomers won't be able to detect them until it is too late to take action. The risk is minute but ever present.

So when we gaze at the delicate beauty of a great comet like McNaught, should we feel wonder tinged with fear? Perhaps. One thing is certain: Sooner or later, a comet will threaten life on Earth.

WEB EXTRA Explore a list of other great comets at www.Astronomy.com/toc.

Richard Jakiel *is an avid deep-sky observer who also collects ancient coins. His previous* Astronomy *article was "Observe autumn's best nebulae" in October 2007.*

Journey to the heart of the Milky Way

Astronomers know a supermassive black hole anchors our galaxy's core. But they struggle to understand the origins of fast-moving stars that swarm it. /// **BY JOHN DVORAK**

High winds are the norm at the center of the Milky Way. Astronomers have clocked suns orbiting the galactic core at a staggering 3,000 miles (4,800 kilometers) per second. At this rate, Earth would complete its orbit around the Sun in a mere 3 days. What lurks at the galaxy's core that can accelerate stars to such fantastic speeds?

Astronomers have considered several possibilities. For example, perhaps the center of the galaxy harbors a tight cluster of neutron stars or a gigantic ball of neutrinos. But this and other even more exotic possibilities were eliminated in the spring of 2002, when a star called S2 swept down in its highly eccentric orbit and passed within 17 light-hours of the Milky Way's center — a small distance in galactic terms. In 17 hours, light travels 3 times the distance between Pluto and the Sun.

Only one object is compact enough and has sufficient mass to accelerate stars to such a high speed: a supermassive black hole. Astronomers had suspected for some time that a black hole must lie at the Milky Way's core, but plotting S2's orbit has dramatically strengthened the evidence.

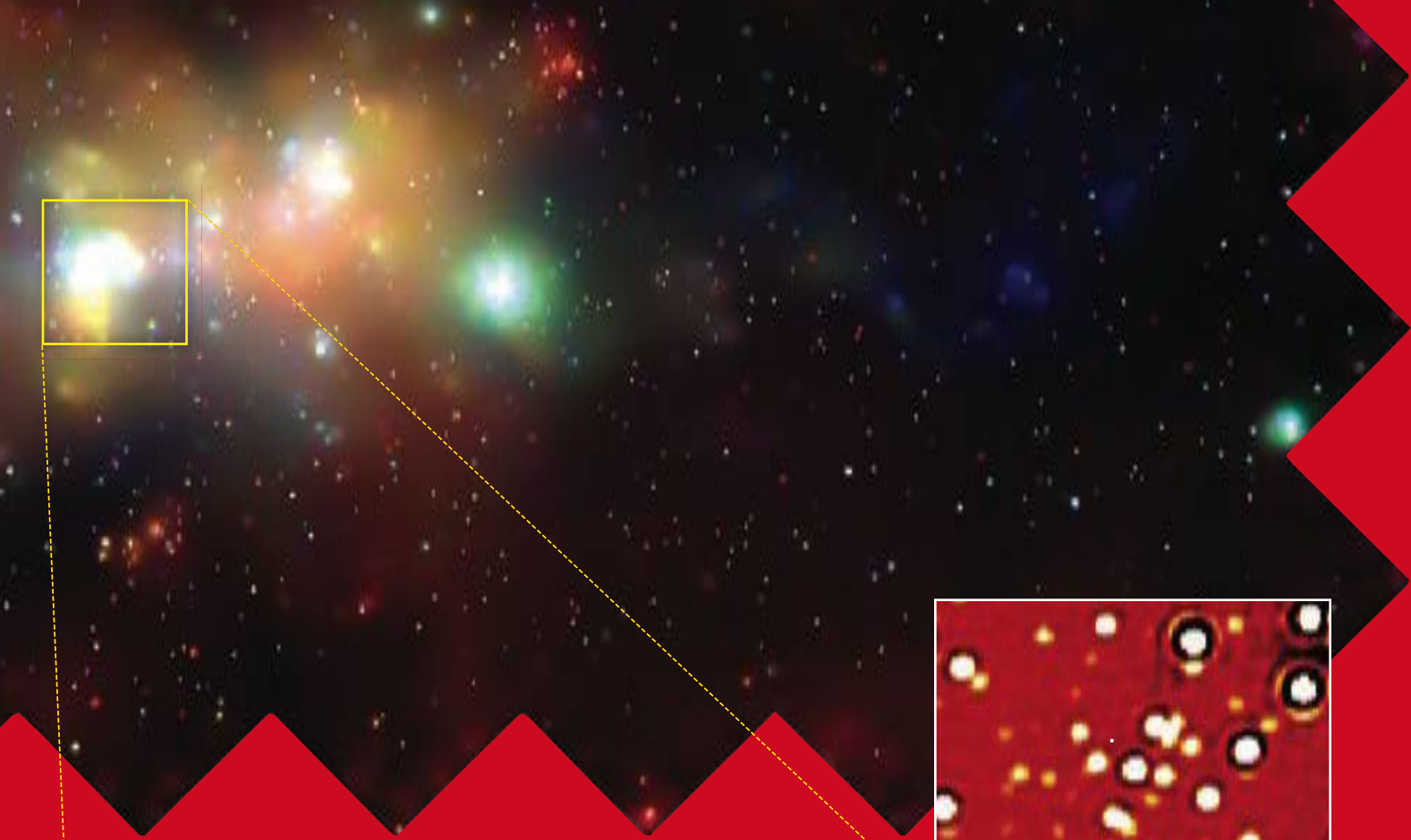
Our central black hole is quaint by the standard of what lurks in the hearts of other galaxies. Observations of the giant elliptical galaxy M87 suggest the presence of a black hole 3 billion times more massive than the Sun. The interaction of two supermassive black holes probably produces the intense X rays streaming from NGC 6240. The Andromeda Galaxy may harbor a black hole of 140 million solar-masses.

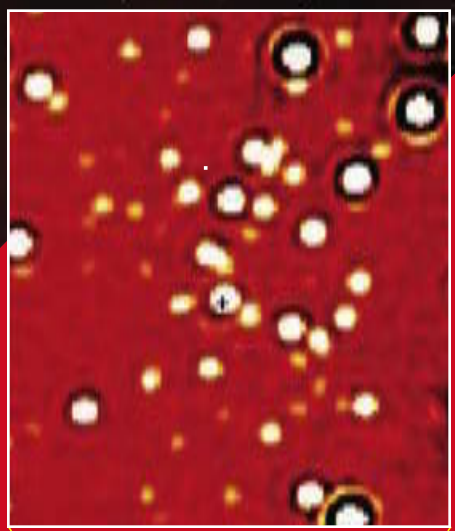
▲ A GALACTIC PANORAMA captured by the Chandra X-ray Telescope reveals gas and stars in the Milky Way's core. The galaxy's central jewel is a massive black hole, located within the central, bright white patch outlined in yellow. New telescope technology allows astronomers to zoom into the very center of the galaxy. NASA/UMASS/D.WANG ET AL.

In comparison, our galaxy's black hole is paltry — containing about 4 million solar-masses. But its nearness means we can study it in detail, including charting the orbits of dozens of stars buzzing around it like bees. The stellar-mass black holes found in some binary star systems are too small to be observed in detail by telescopes any time soon. So, the best chance of seeing what happens in the bizarre neighborhood around a black hole is to study the one at the Milky Way's heart. So far, it has not failed to surprise us.

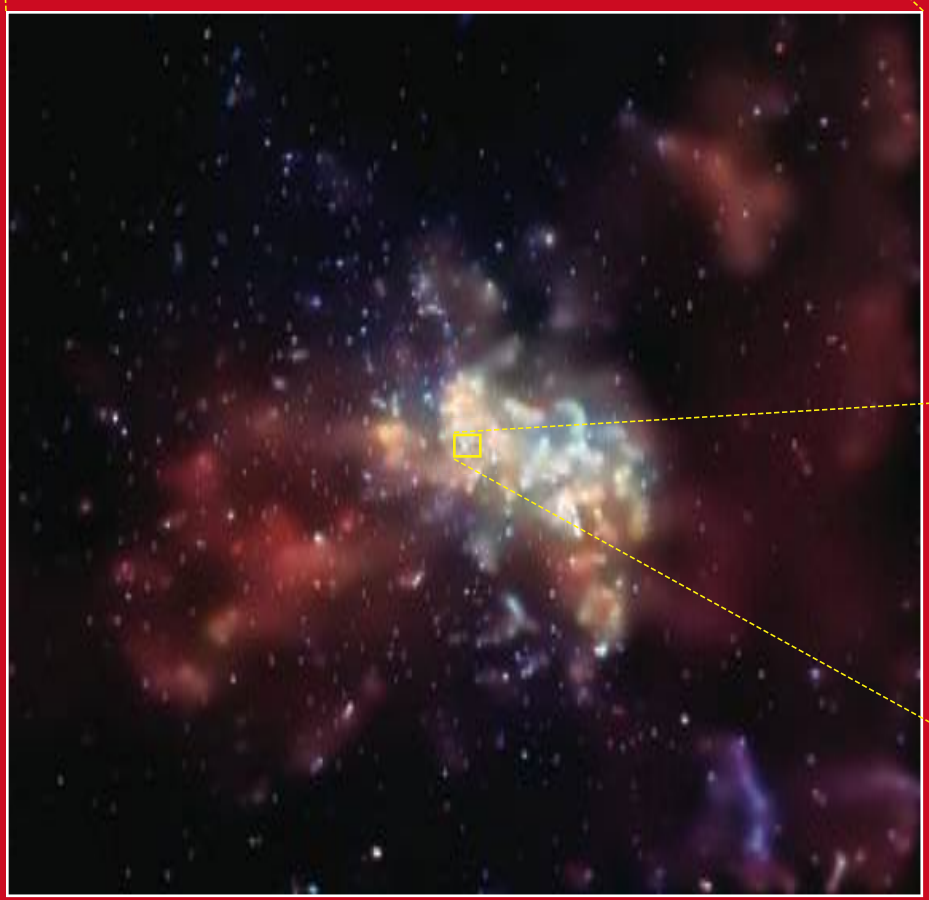
The inner realm

The galactic center lies 26,000 light-years from Earth in Sagittarius, near its western border with Scorpius. It is a region of the

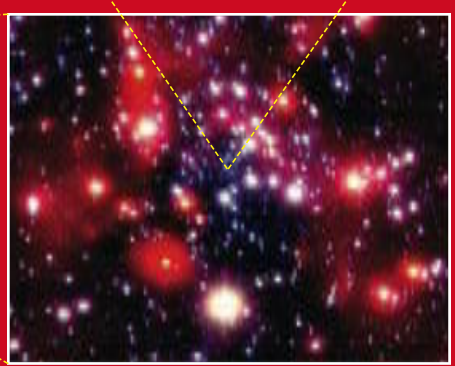




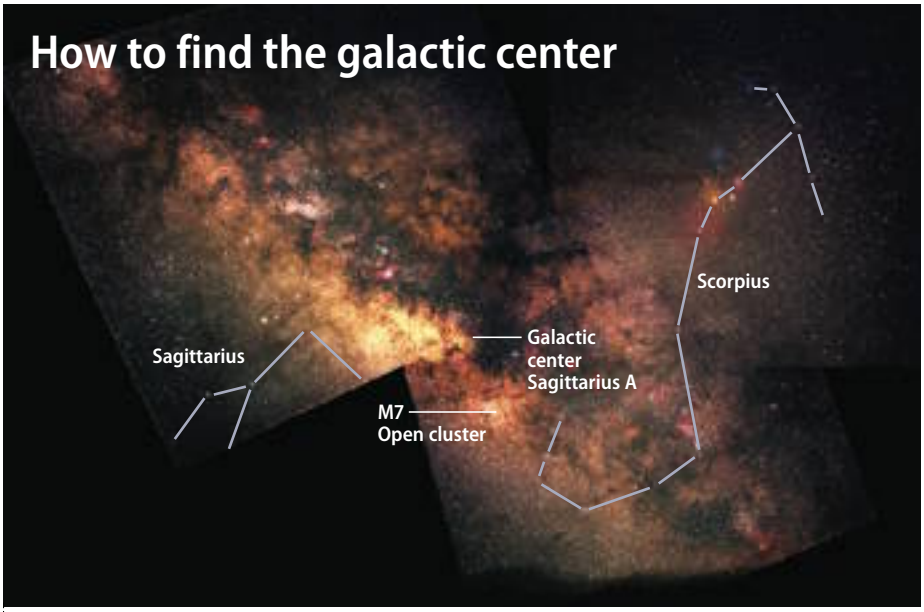
▲ **ASTRONOMERS** imaged individual stars orbiting the galaxy's central black hole, Sagittarius A* (pronounced "A star"). The small cross marks the black hole's location. ESO



▲ **ZOOMING IN AT HIGHER RESOLUTION,** the Chandra X-ray Telescope imaged lobes of hot gas extending dozens of light-years from the galaxy's core. The hot gas is the remnant of past supernova explosions — a common event in the galactic center. NASA/CXC/MIT/F. K. BAGANOFF ET AL.



▲ **ADAPTIVE-OPTICS** technology allows telescopes to resolve individual stars in the Milky Way's crowded core. This image, shot by the European Southern Observatory's 8.2-meter Very Large Telescope, exposes a crowd of hot blue stars and "cool" red stars near the Milky Way's center. Gas glows in the infrared between the stars. ESO



SAGITTARIUS A, AT THE MILKY WAY'S CORE, lies in the constellation Sagittarius east (to the left) of Scorpius. The region is rich with star clusters and nebulae — a perfect place to explore with binoculars under dark skies. GERALD RHEMANN; FINDER CHART: *ASTRONOMY*: ROEN KELLY

sky where bright stars mingle with dark clouds of gas and dust. The actual center is too obscured to reveal much when astronomers observe it in visible light. What we know of it comes from data collected in infrared and radio wavelengths. These wavelengths can pass through the dust and gas and reach Earth-based telescopes.

Radio astronomers have long known that the strongest source of radio energy in the sky, after the Sun, lies at the galactic center. This broad core region is called Sagittarius A, often abbreviated as Sgr A.

Sgr A hosts dozens of individual radio sources. One is called Sagittarius A*, pronounced "Sagittarius A star." It lies at the very center of the galaxy — the presumed location of the supermassive black hole. Everything else rotates clockwise (from Earth's point of view) around this point. It lies at the dynamic center of the galaxy. And it is a very busy neighborhood.

Surrounding Sgr A* at a distance of several light-years, a shell of dust rotates counterclockwise, opposite to the galaxy's general rotation. Lying inside the shell, and turning in the same direction, is a small spiral structure with three arms. Each arm is a stream of hot gas set aglow by nearby stars. The gas flows toward the center of the spiral where Sgr A* lies. Radio images taken a few years apart revealed the spiral is rotating. More recently, a close-up look at Sgr A* with new imaging technology indicated the amazingly powerful gravity of the object the spiral encircles.

John Dvorak *operates a telescope atop Mauna Kea Volcano for the Institute for Astronomy at the University of Hawaii.*

Stellar race track

In 2002, a team of astronomers led by Reinhard Genzel of the Max Planck Institute for Extraterrestrial Physics in Garching, Germany, published the first scientific paper announcing S2's 17-light-hour close encounter with Sgr A*.

OUR CENTRAL BLACK HOLE IS QUAINT by the standard of what lurks in the hearts of other galaxies.

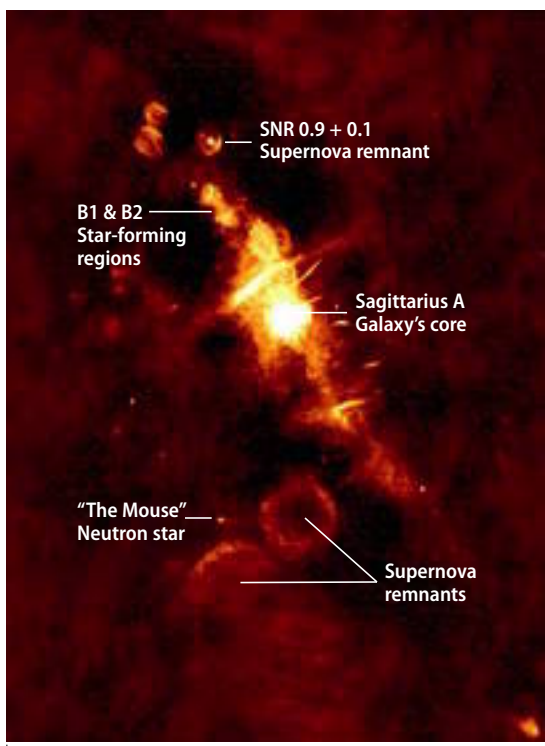
Using the European Southern Observatory's Very Large Telescope (VLT) in Chile, Genzel's group caught S2 as it rounded Sgr A* at a fantastic speed. The VLT's adaptive optics counteracts atmospheric distortion, enabling the astronomers to measure S2's position with unprecedented accuracy.

For the previous decade, the astronomers had been plotting S2's orbit, mostly with ESO's 3.6-meter New Technology Telescope. The orbital positions allowed them to calculate S2's orbital period around Sgr A* as about 15 years. The orbit is quite eccentric, meaning it swoops in to within 17 light-hours at pericenter — its point of closest approach to Sgr A* — but then sweeps outward from the center to a distance of some 10 light-days at its farthest point. To produce such an orbit requires a compact black hole with about 4 million solar-masses.

Genzel and his colleagues were not the only ones tracking S2 and the many other stars zipping around Sgr A*. Astronomer Andrea Ghez's Galactic Center Group at UCLA has studied S2 and its motions with the 10m Keck Telescope. In 2000, for example, the team reported evidence that S2's path is curved — early evidence S2 is orbiting something at the galactic center. The UCLA team later discovered S2's close orbital distance to SgrA* at about the same time as Genzel and his colleagues.

Stars of mystery

Dogged observations in recent years by Genzel, Ghez, and others paint a fascinating picture of the flurry of activity around Sgr


SNR 0.9 + 0.1 Supernova remnant
B1 & B2 Star-forming regions
Sagittarius A Galaxy's core
"The Mouse" Neutron star
Supernova remnants

RADIO ASTRONOMY first displayed the Milky Way center's amazing complexity: remnants of supernova explosions and vast clouds of gas and dust in which stars are forming. W. M. GOSS/C. LANG/VLA/NRAO

A*. One of the most challenging observations astronomers have performed on the galactic center stars is spectroscopy. A spectrum is valuable because it reveals much about a star's composition, age, and mass.

Gathering enough light to take a good spectrum requires tracking the star through a narrow slit precisely fixed on the same spot for hours. Any small shift in the slit's position contaminates the spectrum with light from other sources. Spectroscopy is especially challenging in the crowded star field around Sgr A*, where the density of stars is more than a million times higher than in our stellar neighborhood.

That is why it was a major achievement when, in 2003, Ghez took a spectrum of S2 with the Keck Telescope, using its adaptive-optics system. The slit trained on the star was only 0.04 inches wide. Keeping the slit locked on S2 was like aiming a gun sight on an object the size of a basketball 1,000 miles (1,600 km) away.

The spectrum revealed S2 to be a heavyweight, main-sequence star 15 times the Sun's mass. Such large stars exhaust their hydrogen supply quickly — in this case, in less than 10 million years. That means S2 must be younger than 10 million years. The star also has a very hot atmosphere, as do other stars orbiting close to Sgr A*. This also indicates a relatively young age.

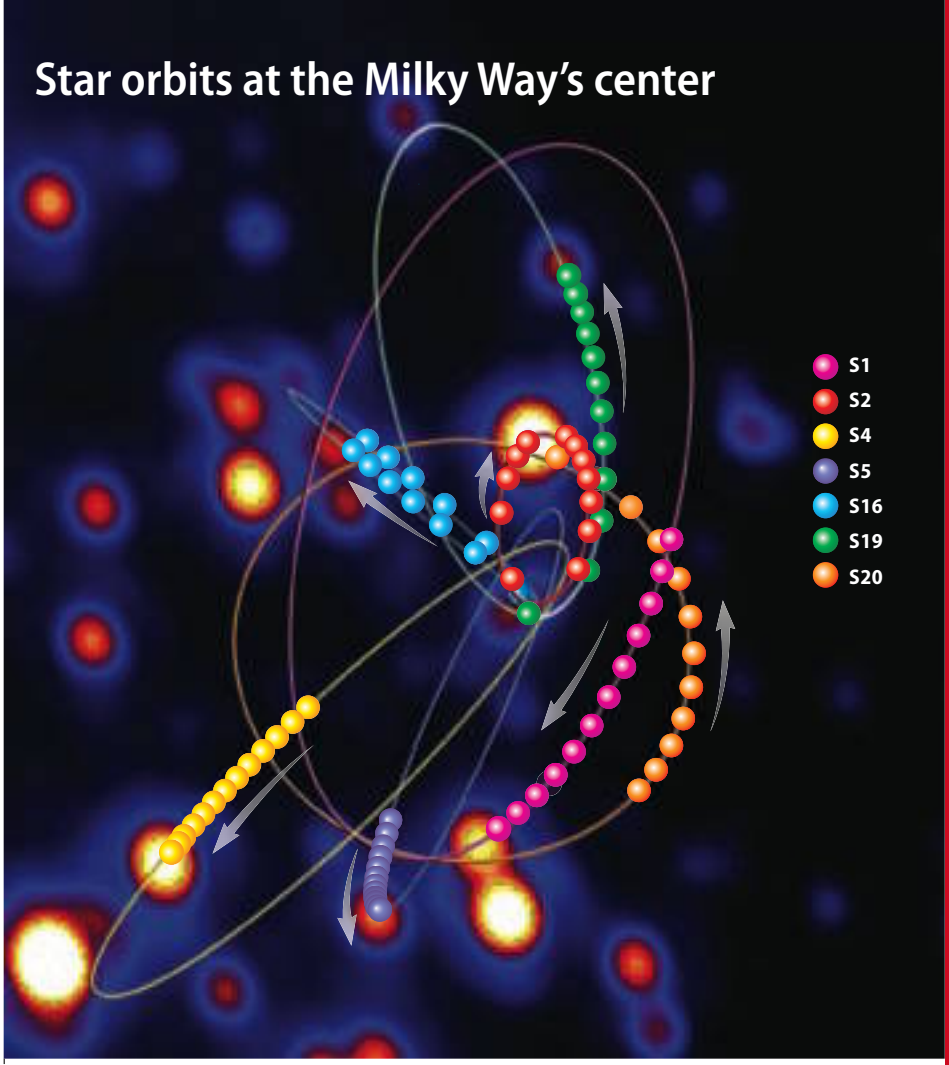
In short, these stars formed between 3 and 6 million years ago. This raises a major problem: Why are such young stars orbiting so close to Sgr A*, a region of intense magnetic fields and strong gravitational forces that would normally inhibit star formation?

Stellar masquerade

One possible explanation is that S2 and its companions may be old stars masquerading as young ones — "a phenomenon we understand quite well in Los Angeles," Ghez once quipped to a science reporter.

In this case, what seem to be young stars are actually the cores of older suns that collided and merged. The collisions could have stripped away the suns' cool, outer layers, exposing their hot interiors. The result would be a cluster of massive stars that appear much younger than they really are.

But there's a problem with this scenario. A collision violent enough to strip away the outer layers should also annihilate both stars and leave only a trail of hot gas. And so astronomers have proposed alternatives. For example, perhaps the stars formed elsewhere and migrated inward under the black hole's gravitational pull.



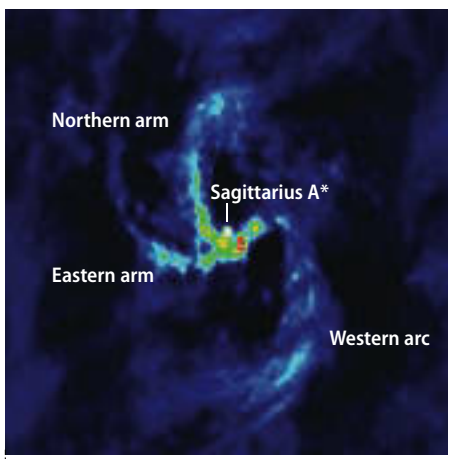
DOZENS OF YOUNG STARS orbit at high speeds around the galaxy's central black hole. By plotting the stars' positions over a period of years, astronomers determined their orbits and the presence of the massive black hole they encircle. ANDREA GHEZ (UCLA)

The problem with this alternative is that most active star formation in the Milky Way occurs far from the core, in its spiral arms. It would take the stars too long to migrate as close to the center as S2.

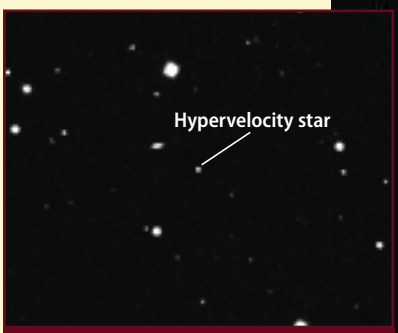
Dense dust clouds do lie closer to Sgr A* than the spiral arms, to within a few dozen light-years. Stars are probably forming inside of them. It's conceivable that a cluster of young stars could spiral down to within a few light-years of the center — and do so in less than 10 million years.

The problem here is that to get closer to the black hole, the stars would have to shed angular momentum — the force that keeps planets in nice, safe orbits around stars instead of "falling" directly into them.

One way to lose angular momentum is to bump into other stars. But it's difficult to imagine how stars could endure this process and migrate to within light-hours of Sgr A* without being destroyed. Besides, the process should leave behind a trail of stars toward Sgr A* for a long distance, something astronomers have not yet seen. Instead, the shell of stars orbiting close to Sgr A* has a definite outer edge.



AT THE GALAXY'S NUCLEUS lies a rotating "mini-spiral" of gas, as shown in this image created from radio emissions in the central 10 light-years of the galaxy. NRAO/AUI



THE MMT OBSERVATORY in Tucson captured a star exiting the galaxy at 1.5 million mph (2.4 million km/h). Astronomers hypothesize that only a black hole could exert enough gravitational muscle to accelerate stars to such speeds. SDSS COLLABORATION

A GRAVITATIONAL TUSSLE with the Milky Way's central black hole flings a star completely out of the galaxy in this artist's depiction. Astronomers have discovered dozens of such "hypervelocity" stars. RUTH BAZINET (CfA)

COSMIC PINBALLS

The high density of stars orbiting close to Sgr A* means that close encounters are likely, producing something akin to a colossal pinball game.

As stars pass near each other, mutual gravitational attraction perturbs their orbits. As a result, the stars fly off into new directions. In extreme cases, some are tossed out of the galactic center entirely, streaming away so fast that they will leave the galaxy. These "hypervelocity" stars are rare, but astronomers have found some.

The first ever discovered, in 2005, zips through the galactic halo at more than twice the speed necessary to escape the Milky Way. Today, astronomers know of dozens of hypervelocity stars destined to leave the galaxy's gravitational influence and reside forever in the loneliest part of the universe — intergalactic space.

On average, a star escapes the galactic center about once every 100,000 years. Over the Milky Way's history, about 100,000 suns have suffered this fate. But what happens to those that, instead of being flung out of the galaxy, are tossed inward to the black hole?

According to speculations by a few astronomers, the star could meet a spectacular end. The black hole's intense gravity would stretch an approaching star into the shape of a long, thin pancake and heat its interior. The stretching and heating of the star might ultimately trigger a supernova explosion, although the physical details of this process remain to be worked out.

S2 did not come close enough to the central black hole in 2002 for this to happen. But if its orbit shifts in the future so that it comes much, much closer, calculations suggest it could explode with the power of 100 supernovae. This would produce an explosion so great astronomers have invented a new term for it — a hypernova. Such a close encounter and spectacular explosion happens about once every 10,000 years. Could the remnant of such a colossal blast still be present?

The hypernova would splatter the star's remains remains across space, expanding as a glowing ball of hot plasma many light-years across. Radio astronomers have found just such a plasma shell. It lies near Sgr A*. In fact, Sgr A* is probably inside it. The X-ray spectrum of Sgr A's eastern region, called Sgr A East, shows the dust and gas enriched in heavy elements. This pattern is similar to that produced by a type-II supernova. So, Sgr A East could be the remnant of a hypernova.

The star that exploded — at least, what remains of it — may be the feature in Sgr A known as "the cannonball." It's a neutron star at the northern edge of Sgr A East. The star itself seems to be speeding away from Sgr A* and trailing a plume of hot gas like a speeding artillery shell. — *J. D.*

Star birth in a disk

Another possibility is that Sgr A*'s central cluster stars formed within a rotating disk of gas and dust immediately surrounding the black hole. In fact, some observations suggest most stars in the central cluster orbit roughly in the same plane — an arrangement reminiscent of the major planets in our solar system. The planets formed in a disk of gas and dust, so perhaps S2 and its fellow travelers did, too.

However, not all astronomers agree the central cluster has a disk-like structure. Another caveat: To spawn stars, the disk would need to be dense enough to withstand the black hole's tidal forces.

Another possible source for Sgr A*'s companion stars could have been dust clouds circling at high speed within a few light-years of the galactic center. Collisions between the clouds could have spawned shock waves, triggering star formation.

Then, collisions between the clouds, and the new stars embedded within them, to lose angular momentum and settle into orbits around the black hole. Finally, the galactic core's strong magnetic field could have gradually swept the leftover interstellar dust and gas away from the black hole. What would remain is a disk of young stars in close orbits to Sgr A*.

This scenario explains much of what astronomers see in the galactic core, although not all. UCLA astronomer Brad Hansen thinks he has a viable alternative explanation: Young, hot stars ended up closer to the Milky Way's central black hole because a second, smaller black hole dragged them there.

This scenario starts in a crowded young star cluster, dozens of light-years from Sgr A*. Collisions between big stars in the cluster's core form an intermediate-mass black hole in the range of 1,000 to 10,000 solar-masses. Gradually, the black hole migrates toward the galactic center, dragging its cargo of "hostage stars" with it. Hansen argues this is the only way to quickly transport young, massive stars into the galactic center from an outside star-birth location.

All the black hole ferry scenario lacks is hard evidence. If a black hole orbits the primary black hole in the galactic core, its presence might be detectable. Its tug on Sgr A* might cause a detectable wiggle. Clearly, astronomers still have a lot of work left to fully understand the processes at work in the galactic core.

Seeing the event horizon

Fast-moving stars like S2 remain the best evidence that a black hole lies at the heart of the Milky Way. Other evidence includes periodic bursts of infrared light from Sgr A*. The bursts suggest the black hole spins, completing a turn every 17 minutes. Astronomers have also detected strong radio pulses coming from Sgr A* they attribute to packets of ultra-hot gas and dust falling into the black hole.

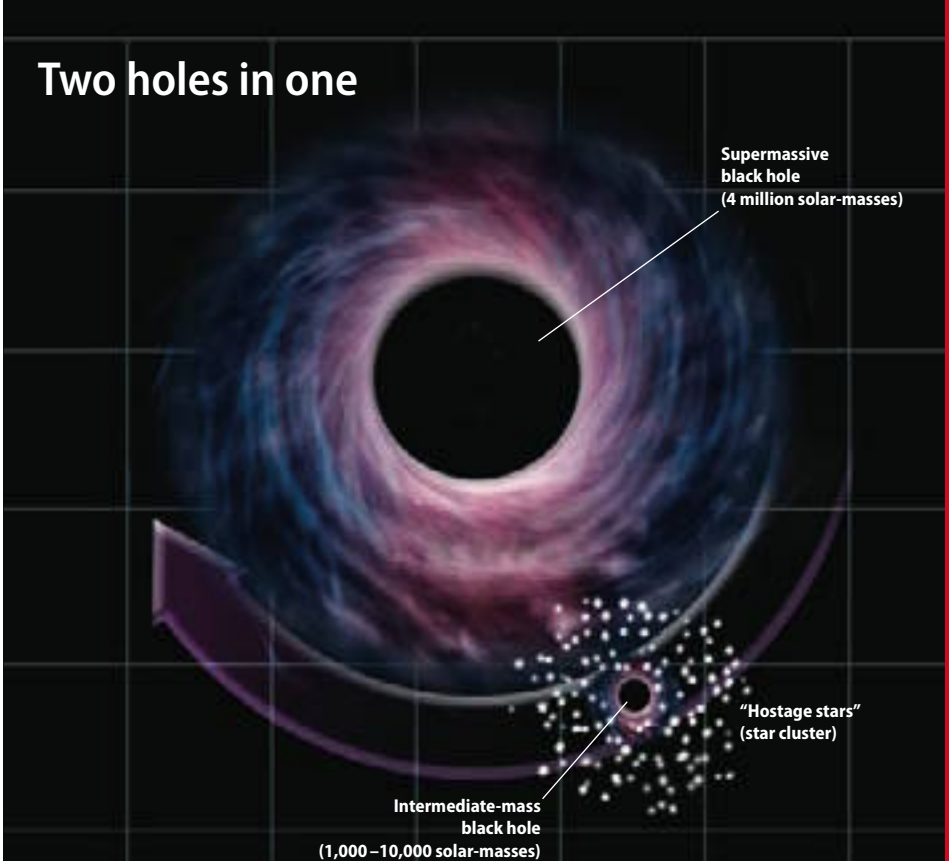
But this is all still circumstantial evidence. The definitive proof might come if astronomers could actually image the black hole's event horizon, the point beyond which no light or matter can escape.

Observing in the radio spectrum at shorter and shorter wavelengths will reveal more details in the galactic core. Also, shorter radio waves scatter less as they pass through surrounding clouds of dust and gas. These two facts combine to create a fortunate set of circumstances for imaging the black hole.

It's likely the most detailed and clearest images of Sgr A* will be seen at wavelengths of about .04 inches (1 millimeter). Radio astronomers are now altering their ground-based instruments to detect this wavelength. If they succeed in imaging the black hole, it will be a silhouette of the event horizon against a background of radiating plasma and stars.

Light follows a highly curved path near black holes, so the size of the silhouette should be about 5 times larger than the actual event horizon. It might be an oval, depending on which direction the spin axis points. Bright rings or arcs, formed as a result of gravitational "lensing" of light from behind the black hole, might be visible just outside the silhouette. We might see other oddities, such as streams of gas on the black hole's backside.

Whatever the result, imaging the Milky Way's central black hole will be a crucial test of general relativity, put the existence of black holes on a firmer footing, and perhaps reveal important new insights about the evolution of galactic cores. A failure to see it will bring into question what we understand about the heart of our own galaxy — including the origins of the high-speed roller derby of young stars whizzing around its center.


Two holes in one
Supermassive black hole (4 million solar-masses)
"Hostage stars" (star cluster)
Intermediate-mass black hole (1,000 –10,000 solar-masses)

TO EXPLAIN THE MYSTERY of how young stars reached the Milky Way's core, astronomer Brad Hansen of UCLA proposed an unconventional solution: an intermediate-sized black hole dragged them in as a group. The cluster continues to orbit the galaxy's central supermassive black hole. *ASTRONOMY:* ROEN KELLY

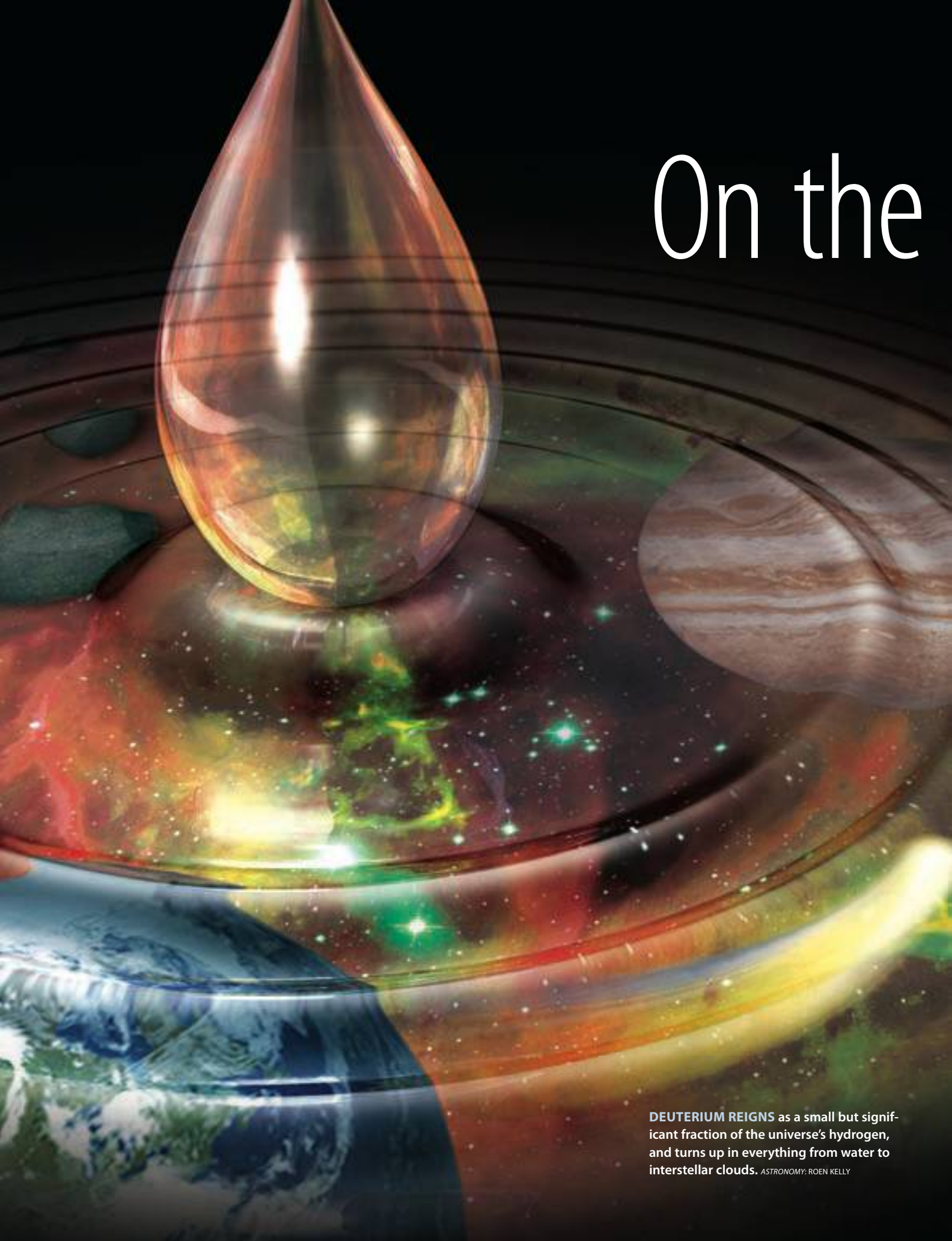
WEB EXTRA UCLA's Brian Hansen makes the case for a second black hole in the galactic core at www.Astronomy.com/toc.

STARS COULD FORM near a black hole if a sufficiently dense disk of dust and gas surrounded it. Despite the forces exerted by the black hole's tremendous gravity, local regions of the disk could collapse and trigger star birth. ILLUSTRATION: NASA/CXC/M. WEISS

AT THE END of the star-birth process, a cluster of hot young stars remains around the black hole, even though the gas from which they formed has dissipated.

ILLUSTRATION: NASA/CXC/M.WEISS

On the



DEUTERIUM REIGNS as a small but significant fraction of the universe's hydrogen, and turns up in everything from water to interstellar clouds. *ASTRONOMY:* ROEN KELLY

trail of hydrogen's heavy sibling

With twice the mass of ordinary hydrogen, deuterium plays a weighty role in trying to comprehend the early universe, galactic evolution, and life's extent.

/// **BY BRUCE DORMINEY**

In less time than it takes to hard-boil an egg, the nuclear furnace that followed the Big Bang spawned the lightest nuclei of the periodic table. The universe's first 3 minutes saw hydrogen, deuterium, helium-3, helium-4, and lithium-7 come into existence. Everything heavier than helium — from lithium, through life-giving carbon and oxygen, to precious gold and beyond — astronomers call "metals."

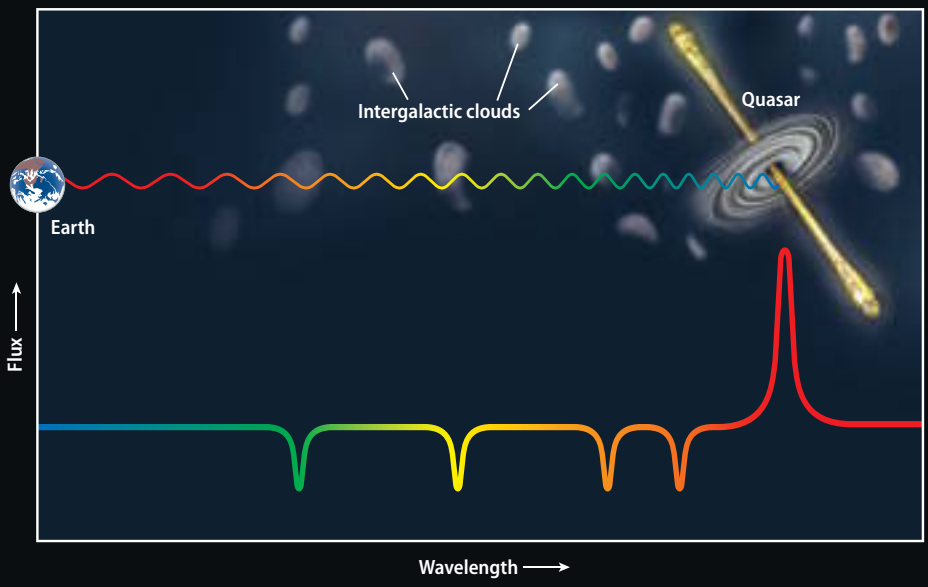
But of all the elements out there, few capture astronomers' interest more than deuterium — a hydrogen isotope. It serves as a cosmological tracer of both the density of matter in the early cosmos and the chemical evolution of the Milky Way. Its abundance holds clues to the nature of Big Bang nucleosynthesis, the chemical evolution of galaxies, and possibly the universe's abundance of life-bearing planets. The trouble is, deuterium is difficult to detect, particularly outside our galaxy.

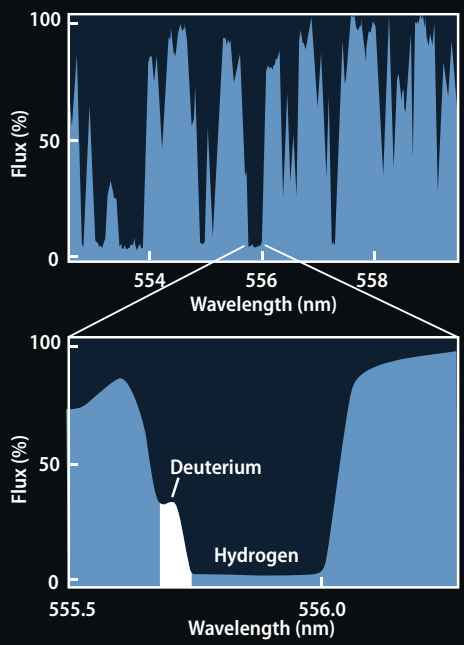
The third most abundant element in the early universe, deuterium reached its pinnacle when the cosmos was just 17 minutes old. That was its primordial tipping point. No more of this fragile nucleus — composed of a proton and neutron — would be created. Deuterium has been on a downhill slide ever since because the atomic processes needed to build complex nuclei always destroy it and never create it.

In nature, deuterium gets destroyed in reactions with protons, neutrons, and other nuclei inside stars and substellar-mass brown dwarfs in a process known

Bruce Dorminey *is the author of* Distant Wanderers: The Search for Planets Beyond the Solar System *(Copernicus Books, 2001). His most recent* Astronomy *article was "The Large Binocular Telescope opens both eyes" in December 2007.*

Deuterium in intergalactic space





▲ **A DISTANT QUASAR** shines across the universe, lighting up tenuous intergalactic clouds that lie between the quasar and Earth. The clouds have a smaller redshift than the quasar, so they absorb radiation at wavelengths shorter than the quasar's emission. *ASTRONOMY:* THEO COBB

◀ **A SPECTRUM** of the quasar QSO 1937–1009 taken with the Keck I Telescope reveals lots of Lyman-alpha absorption from an intergalactic cloud at a redshift of 3.572. SCOTT BURLES (UNIVERSITY OF CHICAGO) AND DAVID TYTLER (UC, SAN DIEGO)

◀ **A LITTLE DEUTERIUM** shows up in the spectrum at a wavelength slightly shorter than that of hydrogen's main Lyman-alpha absorption. The discrepancy arises because deuterium photons have energies 0.0272 percent greater than hydrogen photons. SCOTT BURLES (UNIVERSITY OF CHICAGO) AND DAVID TYTLER (UC, SAN DIEGO)

as astration. Our Sun burned through its supply of deuterium within 1,000 years of its formation, long before it hit the hydrogen-burning main sequence.

Still, enough deuterium survives today to be found in everything from sea water to comets, Jupiter's atmosphere, meteorites, the interstellar medium, high-velocity clouds outside the Milky Way's disk, and the intergalactic medium. Even at its most abundant, however, deuterium is hardly plentiful. Astronomers think the ratio of deuterium to hydrogen, known as the D/H ratio, in the early universe was around 30 parts per million (ppm).

Because the ratio of deuterium to hydrogen has only decreased since Big Bang nucleosynthesis, observed D/H ratios act as fundamental probes of the density and evolution of matter in the universe, from the earliest epochs to the present.

Back to the beginning

"The primordial deuterium abundance probes the baryon [ordinary matter] density when the universe was a few minutes old," says Gary Steigman, an astrophysicist at Ohio State University. "And the Wilkinson Microwave Anisotropy Probe [WMAP] probes the density when the universe was nearly 400,000 years old. We're in perfect agreement with the WMAP data that determines the baryon-density parameter. You might say, 'Gee, the problem is solved. We're on our way to the really important conclusion that our understanding of the universe extends not only back to 400,000 years after the Big Bang, but to the first few minutes. Let's go do something else.'"

Not so fast. Since 1994, observers have scoured the sky for distant, high-redshift quasars that can illuminate the presumably pristine, hydrogen-rich intergalactic medium. So far, they've deemed observations of only five such quasars reliable enough. And the D/H ratios seen in these five cases range from 16 to 40 ppm — hardly what you need to build a consensus on deuterium's primordial abundance.

More than a decade ago, University of California at San Diego astrophysicist David Tytler and his colleagues first detected deuterium in high-redshift quasars with the HIRES spectrograph on the 10-meter Keck I Telescope in Hawaii. Tytler's team has used Keck to find four of the five best lines of sight for deuterium. Astrophysicist Max Pettini of Cambridge University in the United Kingdom and his team uncovered the fifth line of sight with Hubble Space Telescope observations. A possible sixth line of sight turned up after Neil Crighton of the United Kingdom's Durham University analyzed data taken during earlier Keck observations.

"It takes a day to see that you've got deuterium," says Tytler, "but it can take a lot longer to convince yourself you have. Back in those days, we didn't know how hard it was going to be. It's more of a surprise today that we did as well as we did early on."

Tytler's four detections show abundances from 24 to 40 ppm. And the observational errors, which hover around 9 percent, can't explain such a wide range. "The obvious way to explain the data is to say that we just didn't calibrate the data correctly," says Tytler. "Did I underestimate the amount of blending between hydrogen and deuterium, or did I overestimate it?"

At redshifts approaching 3, when the universe was just a third of today's size, deuterium's ultraviolet spectral lines shift into the optical part of the spectrum. That's where things get tough. Detecting deuterium in the optical is somewhat akin to walking an observational tightrope.

Deuterium and hydrogen have optical lines that lie nearly on top of one another.

Fortunately, the deuterium nucleus weighs almost twice as much as ordinary hydrogen. This causes deuterium spectral lines to shift a tiny amount toward the blue relative to hydrogen's spectral lines.

"Looking at a graph of these lines is a mess," says Scott Burles, a former graduate student of Tytler's and now an astrophysicist at MIT. "Most of the time, only a select set of systems have dense-enough atomic hydrogen lines concentrated at the same spot to actually then look for the associated deuterium lines."

But the effort's worth it. Combining the D/H ratio, which provides the density of ordinary matter at high redshift, with the Hubble constant, a measure of how fast the universe is expanding, gives cosmologists the fraction of the universe made of ordinary matter. Using a Hubble constant of 73 kilometers per second per megaparsec, that figure turns out to be roughly 4 percent, leaving 23 percent as dark matter and 73 percent as dark energy.

"For something as important as the primordial deuterium abundance," says Steigman, "I'd like to see a dozen sightlines. But people who have access to Keck would much prefer to find Earth-mass planets around solar-type stars than do the very difficult search for those lines of sight where they can potentially detect deuterium."

JUPITER'S CLOUD TOPS contain a deuterium-to-hydrogen ratio of 21 ppm, implying the solar system formed with a similar ratio. NASA/JPL

Tytler would relish the opportunity to double his observational sightlines, which he says would bring his team's errors down to 3 percent or better. But he notes that each new controversy over data actually makes it harder to get telescope time. "We spent well over 50 nights of Keck time, and that's valued at $5 million," he says. "This is one of the bigger telescope projects of the last decade. An astronomical night at Keck is about 8 hours long — [so it requires] 2 nights for one object. But press coverage [of the deuterium data controversy] has slowed the subject down by at least 5 years."

DIRTY ICEBALLS called comets contain a significant fraction of frozen water, and thus a bit of deuterium. Oddly enough, the deuterium-to-hydrogen ratio in comets does not match that in Earth's oceans. NOAO

What's the frequency?

In time, deuterium observations at much longer radio wavelengths may make the optical observations of high-redshift quasars obsolete. Since radio astronomers first detected the 21-cm line of atomic hydrogen in 1951, they have hoped to identify deuterium emission at its corresponding wavelength of 92 centimeters. The wait ended in September 2005, when Alan Rogers and his colleagues at MIT's Haystack Observatory reported the first reliable detection of deuterium's 92-cm line.

In contrast to the tortuous task of separating hydrogen and deuterium emission in the optical, the two isotopes are much easier to differentiate in the radio. At these wavelengths, the emission arises when the spin of the atom's electron flips. Yet it still took Rogers and his team 6 months before their dedicated array of 1,152 dipole antennae captured the first hint of deuterium emission in the direction opposite from the Milky Way's center. The observation yielded a D/H ratio of 23 ppm.

Eventually, Kris Sigurdson, a particle physicist and cosmologist at the Institute

OCEANS AND CLOUDS dominate this view of North America and its surroundings. In all this water, a tiny percentage of deuterium replaces the normal hydrogen. NASA/GSFC

GLOWING GAS CLOUDS in the Milky Way contain more deuterium than astronomers had thought, suggesting much of the interstellar medium may have fallen into the galaxy from outside. T. A. RECTOR/UNIVERSITY OF ALASKA ANCHORAGE/WIYN/NOAO/AURA/NSF

N. A. SHARP/REU PROGRAM/NOAO/AURA/NSF

EXPANDING supernova remnants heat the stuff between stars, liberating deuterium from dust grains and returning these atoms to the interstellar medium.

for Advanced Study in Princeton, New Jersey, would like to look for deuterium in absorption lines from photons in the cosmic microwave background. He hopes to make observations at redshifts between 20 and 200, during the cosmic Dark Ages (before most stars and galaxies formed).

Deuterium at such early times would have an even more pristine abundance than in the intergalactic medium. But a radio array capable of such feats would have to be a few times larger than the proposed Square Kilometer Array, which remains in the planning stages.

Much closer to home, we know the interstellar gas in the Sun's vicinity has been recycled through several star generations. The recycling destroys (or astrates) deuterium and creates heavier elements. When deuterium gets destroyed, it gains a proton and becomes helium-3. Measurements of helium-3 in the solar wind and in Jupiter's atmosphere tell astronomers the cloud from which our solar system formed had a D/H ratio of some 21 ppm.

The supernova connection

The Sun lies inside multiple supernovae remnants, in a cavity of ionized hydrogen gas roughly 600 by 1,900 light-years wide. Known as the Local Bubble, it apparently formed some 10 to 15 million years ago by winds and ejecta from perhaps as many as 20 supernovae. Astronomers think the exploded stars originated in the Scorpius-Centaurus Association, a group of hot, massive O- and B-type stars, now located some 400 light-years away.

"Inside the Local Bubble cavity, [initially] the supernova ejecta — roughly 10 times the Sun's mass worth of stuff — is totally free of deuterium," says Brian Fields, an astrophysicist at the University of Illinois at Urbana-Champaign. "Then it quickly sweeps up material around it which will contain deuterium. All this stuff gets mixed up into this ever-growing blast wave. And eventually, the whole supernova remnant comes to a stop and gets turbulently churned up."

Since astronomers first detected deuterium in the interstellar medium in the early 1970s, they've debated how much of the isotope has been processed and destroyed. Until recently, researchers thought the D/H ratio in the local interstellar medium was 15 or 16 ppm. That all changed with the 2006 announcement of results from NASA's Far Ultraviolet Spectroscopic Explorer (FUSE) spacecraft, which ceased observations this past October.

Lighting the FUSE

The recent FUSE figure places the D/H ratio in the galactic disk beyond the Local Bubble 58-percent higher than previous measurements. That's based on 6 years of observations along 47 lines of sight, using background stars to probe for deuterium absorption in the ultraviolet. The background stars ranged from Sirius at a distance of a little more than 8 light-years to HD 90087 nearly 9,000 light-years away.

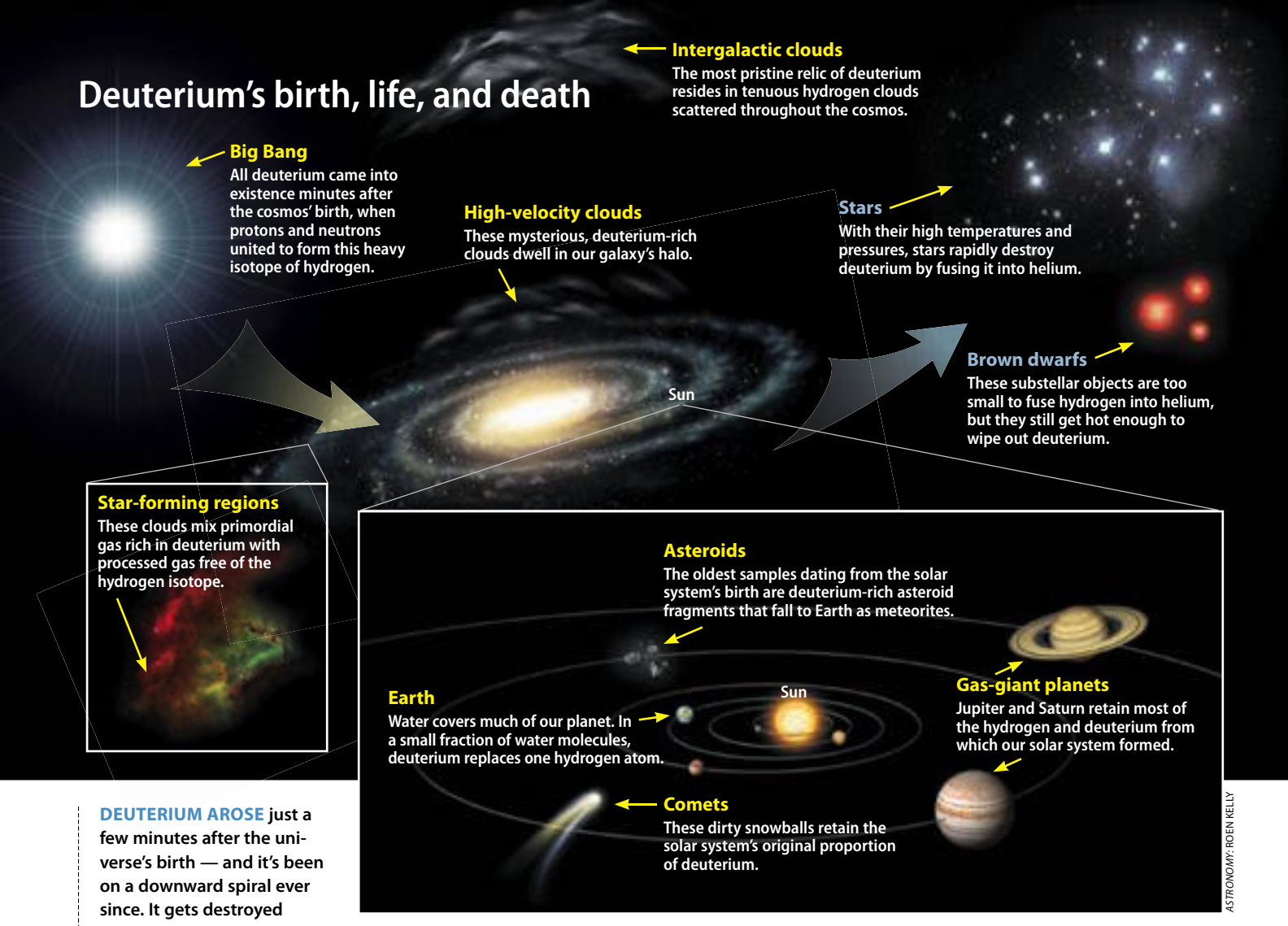
Jeffrey Linsky, an astrophysicist at the University of Colorado at Boulder and leader of the FUSE research team, says that within 300 light-years of Earth, the D/H ratio maintains a constant value of 15.6 ppm. Beyond the Local Bubble, however, the range balloons from 5 to 23 ppm.

What causes such discrepancies? Linsky believes the most likely explanation lies with an idea that dates to 1982. That's when UCLA astrophysicist Mike Jura suggested deuterium can chemically bond with cold interstellar carbon grains, accounting for the depletion observed along certain lines of sight.

Bruce Draine, an astrophysicist at Princeton University and co-author of the FUSE paper, explains that the carbon-deuterium bond is slightly stronger than the carbon-hydrogen bond. So, when a grain gets heated, hydrogen may leave but deuterium will remain. The missing deuterium isn't being destroyed — it's simply being converted to a form FUSE can't detect.

"This is going to shake up our understanding of how the galaxy has evolved," says Linsky. "All of a sudden we are throwing the modelers a curveball. It may force us to change our assumptions concerning stellar-formation rates or the percentage of stars that go through supernovae."

The biggest uncertainty in current galactic models is how much deuterium-rich material falls into the Milky Way's disk. Conventional figures indicate that


Deuterium's birth, life, and death
Intergalactic clouds
The most pristine relic of deuterium resides in tenuous hydrogen clouds scattered throughout the cosmos.
Big Bang
All deuterium came into existence minutes after the cosmos' birth, when protons and neutrons united to form this heavy isotope of hydrogen.
High-velocity clouds
These mysterious, deuterium-rich clouds dwell in our galaxy's halo.
Stars
With their high temperatures and pressures, stars rapidly destroy deuterium by fusing it into helium.
Brown dwarfs
These substellar objects are too small to fuse hydrogen into helium, but they still get hot enough to wipe out deuterium.
Sun
Star-forming regions
These clouds mix primordial gas rich in deuterium with processed gas free of the hydrogen isotope.
Asteroids
The oldest samples dating from the solar system's birth are deuterium-rich asteroid fragments that fall to Earth as meteorites.
Earth
Water covers much of our planet. In a small fraction of water molecules, deuterium replaces one hydrogen atom.
Sun
Gas-giant planets
Jupiter and Saturn retain most of the hydrogen and deuterium from which our solar system formed.
Comets
These dirty snowballs retain the solar system's original proportion of deuterium.
ASTRONOMY: ROEN KELLY

DEUTERIUM AROSE just a few minutes after the universe's birth — and it's been on a downward spiral ever since. It gets destroyed rapidly in stars and brown dwarfs, and survives only in limited environments, including water, giant planets, comets, and hydrogen-rich clouds.

between 25 and 50 percent of the interstellar medium's gas originates outside the galaxy. But some modelers think that number is higher.

"In my galactic chemical-evolution models," says Donatella Romano, a theoretician at Italy's Bologna Observatory, "roughly 75 percent of the total gas observed in the local disk today is unprocessed gas coming from outside. This gas mixes with roughly 25 percent of astrated material ejected from dying stars via supernova explosions, or more quietly through stellar winds [near the end of a star's life] and through ejection of planetary nebulae.

"This relatively unprocessed, deuterium-enriched infalling gas is estimated to have a D/H ratio of 22 ppm," adds Romano. "How much has been accreted since the Milky Way's formation remains an open question. But it is certain that the old, closed-disk models of galactic chemical evolution are now woefully outdated."

Expanding life's horizons

And if the interstellar medium is more inhomogeneous than previously thought, astronomers also may have to reconsider where life could arise in the galaxy. The conventional view has been that our Sun, a metal-rich G-dwarf star, lies in a serendipitous "Goldilocks"-like location, some 26,000 light-years from the galaxy's center.

Much closer, and Earth might have been subjected to harmful radiation from supernovae, which could impede the evolution of a bio-friendly atmosphere. Farther out, and metals might not have been plentiful enough to form planets like our own. Thus, the FUSE results muddy the waters because the interstellar medium's gaseous make-up seems to vary much more from place to place than astronomers had thought.

"The simplified thinking," says Fields, "is there's a constant decline in galactic metallicities, from a high in the central region of the galaxy to low metallicities in the outer regions. If the galaxy is poorly mixed, that means local conditions vary widely. So there's more opportunity to form planets in lots of different places."

In contrast, current theories of planet formation and the evolution of life usually involve metal-rich stars like the Sun. After all, we, like our planet, are brimming with iron. Thus, Linsky wonders: "If our understanding of galactic chemical evolution is going to change, then the whole question of the metallicity of the galaxy may change. Did the metals come in at the galaxy's beginning, uniformly over time, or only recently? That determines how many stars are going to have high metal abundances and thus how many [stars harbor] planets."

In the end, the search for deuterium and its abundance may not be as academic as it once seemed. In fact, this elusive isotope of hydrogen ultimately may tell us as much about the evolution of planets and life in our galaxy as it does about standard models of the universe. A

BY MARTIN RATCLIFFE AND ALISTER LING

FEBRUARY 08

Shadow play on the Moon

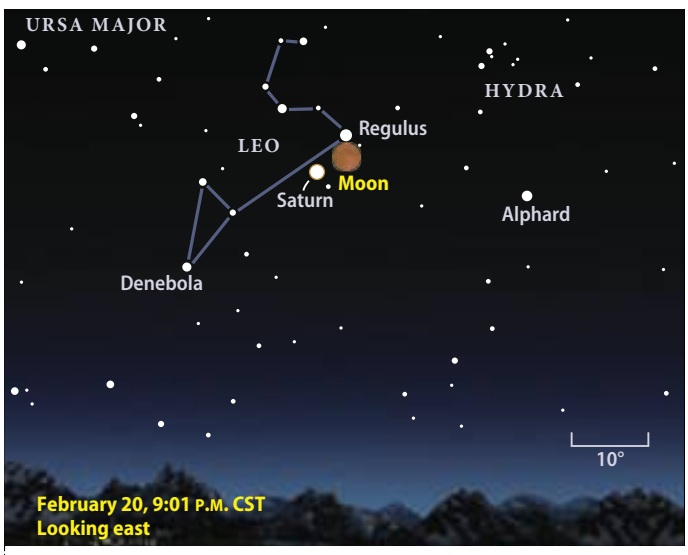
The night sky offers a seemingly endless parade of great sights for both casual and keen observers. This February, Mars beckons viewers with one last chance to see fine surface details through small- and medium-sized telescopes. Not to be outdone, Saturn puts on its best show of 2008.

Two events of a more transitory nature will generate the most attention, however. The Moon will turn red February 20/21 as it passes through Earth's shadow. This total lunar eclipse will provide spectacular views for those using binoculars or just their eyes. Another spectacle — the close approach of Venus and Jupiter in the early morning sky — gives an elegant study in the relative motions of solar system bodies.

Let's start our night-sky tour with the **total lunar eclipse**. Although this is the third total eclipse in the past 12 months, it's the first visible from all of North America. The previous two favored only half the continent. As a bonus this time, golden Saturn lies near the eclipsed Moon.

40 Total eclipse of the Moon
45 Lunar crater Cauchy
46 When to view the planets
46 Saturn shines big and bright
46 Comet 46P/ Wirtanen
47 Asteroid Hebe
47 Venus meets Jupiter

Visible to the naked eye
Visible with binoculars
Visible with a telescope



THE MOON GLOWS RED among the background stars of Leo during the February 20/21 total lunar eclipse. The bright planet Saturn also lies nearby. *ASTRONOMY:* ROEN KELLY

AUGUST'S LUNAR ECLIPSE, seen here, put on a nice show from western North America. This month's total eclipse, in contrast, favors the whole continent. STEPHEN JAMES O'MEARA

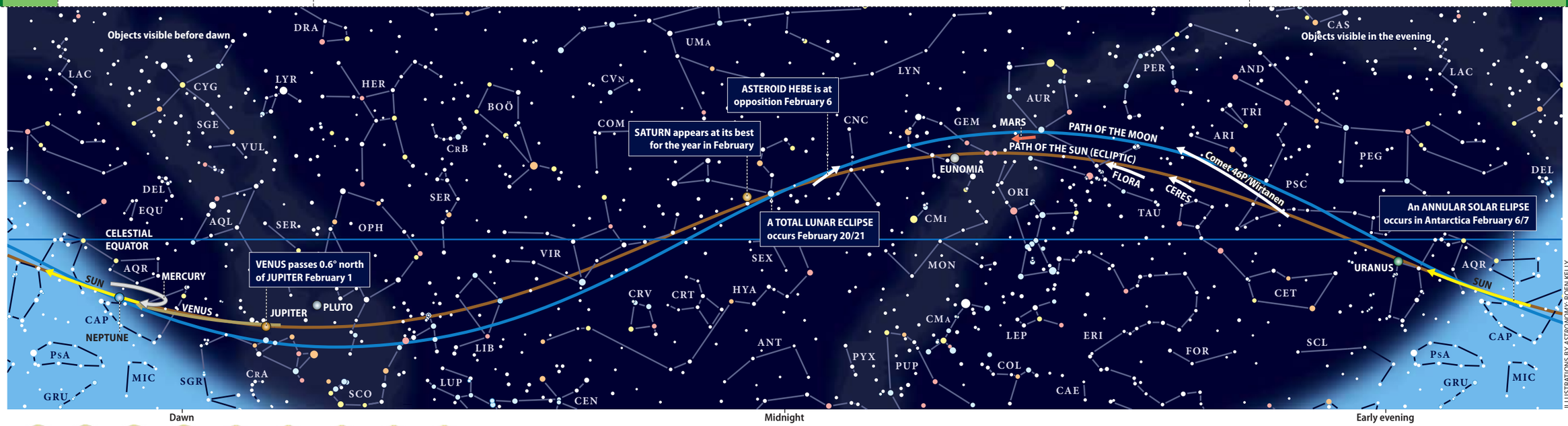
Understanding what causes a lunar eclipse is easy once you grasp the three-dimensional arrangement of the Sun, Earth, and Moon. The Sun radiates lots of light throughout the inner solar system, and our opaque planet casts a shadow into space. Typically, a Full Moon passes untouched to the north or south of this shadow, but not so this month. The Moon plows right into the shadow, where direct sunlight can't reach.

Earth's dark shadow creeps across the lunar surface starting at 8:43 P.M. Eastern Standard Time February 20. Along the East Coast, the Moon already stands more than 30° high in the dark eastern sky then. For

— *Continued on page 45*

Planets this month

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and colored dots show motions and locations of solar system objects during the month.



ILLUSTRATIONS BY ASTRONOMY: ROEN KELLY

[09] [08] [07] [06] [05] [04] [03] [02] [01]

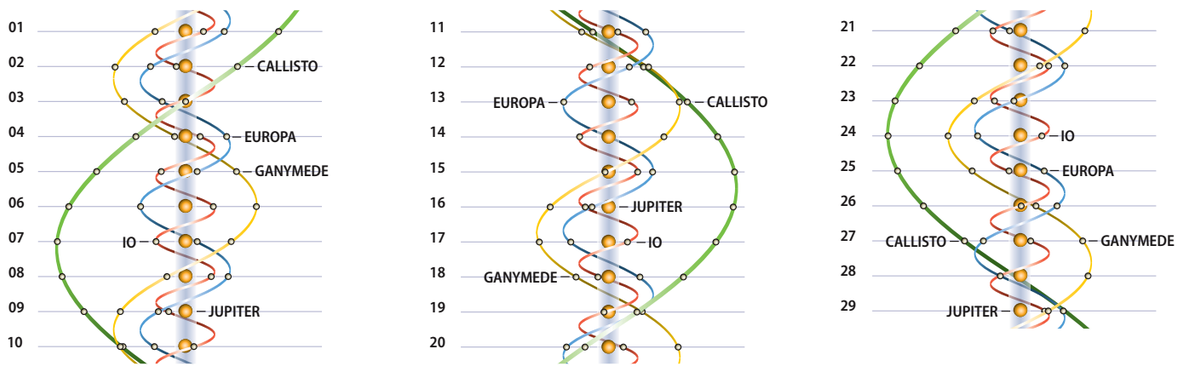
To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved blue line.

[29] [28] [27] [26] [25] [24] [23] [22] [21] [20] [19] [18] [17] [16] [15] [14] [13] [12] [11] [10] [09] [08] [07]

PLANETS	MERCURY	MERCURY	VENUS	MARS	MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
Date	February 15	February 29	February 15	February 1	February 29	February 15	February 15	February 15	February 15	February 15
Magnitude	1.6	0.1	−3.9	−0.6	0.2	−1.9	0.3	5.9	8.0	14.0
Angular size	9.8"	7.5"	11.8"	12.0"	9.1"	33.3"	20.0"	3.4"	2.2"	0.1"
Illumination	16%	51%	88%	95%	91%	100%	100%	100%	100%	100%
Distance (AU) from Earth	0.688	0.895	1.410	0.778	1.024	5.912	8.305	21.010	31.027	31.968
Distance (AU) from Sun	0.382	0.448	0.726	1.616	1.639	5.231	9.278	20.096	30.041	31.417
Right ascension (2000.0)	20h43.4m	21h00.8m	19h54.4m	5h33.0m	5h53.5m	18h55.1m	10h33.1m	23h14.2m	21h36.9m	18h01.8m
Declination (2000.0)	−14°58'	−16°44'	−20°48'	26°40'	26°16'	−22°44'	11°05'	−5°43'	−14°32'	−17°09'

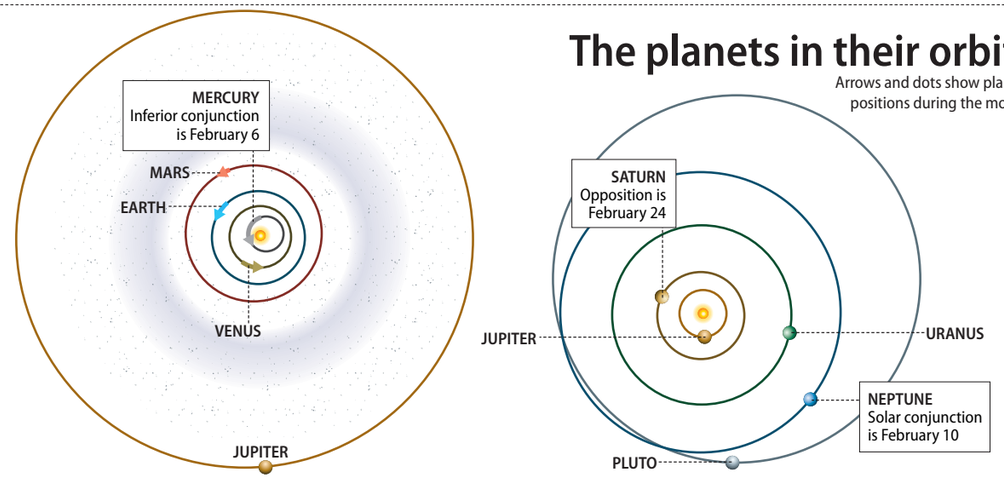
Jupiter's moons

Dots display positions of Galilean satellites at 5 A.M. EST on date shown. South is at top to match the view through a telescope.



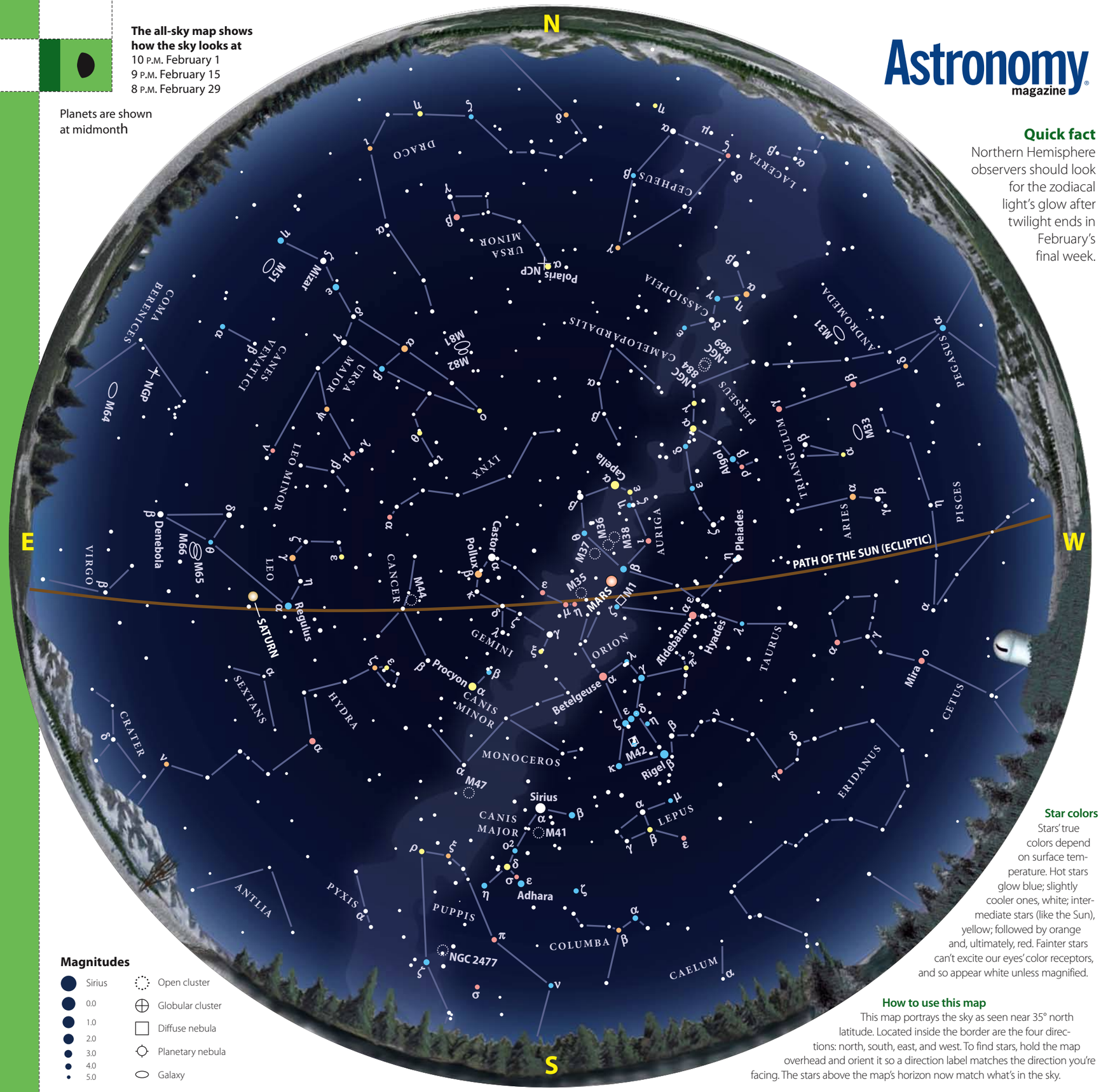
The planets in their orbits

Arrows and dots show planets' positions during the month.



The all-sky map shows how the sky looks at
10 P.M. February 1
9 P.M. February 15
8 P.M. February 29

Planets are shown at midmonth



Magnitudes

Sirius
0.0
1.0
2.0
3.0
4.0
5.0

Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

Star colors
Stars' true colors depend on surface temperature. Hot stars glow blue; slightly cooler ones, white; intermediate stars (like the Sun), yellow; followed by orange and, ultimately, red. Fainter stars can't excite our eyes' color receptors, and so appear white unless magnified.

How to use this map
This map portrays the sky as seen near 35° north latitude. Located inside the border are the four directions: north, south, east, and west. To find stars, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

Astronomy magazine

Quick fact
Northern Hemisphere observers should look for the zodiacal light's glow after twilight ends in February's final week.

NOTABLE OBSERVING DATE:
February 20/21, the last total lunar eclipse until December 2010.

february 08

SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
					[01]	[02]
[03]	[04]	[05]	[06]	[07]	[08]	[09]
[10]	[11]	[12]	[13]	[14]	[15]	[16]
[17]	[18]	[19]	[20]	[21]	[22]	[23]
[24]	[25]	[26]	[27]	[28]	[29]	

ILLUSTRATIONS BY *ASTRONOMY*: ROEN KELLY

01 Venus passes 0.6° north of Jupiter, 8 A.M. EST

The Moon passes 0.6° south of Antares, 1 P.M. EST

04 The Moon passes 4° south of Jupiter, 1 A.M. EST

The Moon passes 4° south of Venus, 7 A.M. EST

06 Mercury is in inferior conjunction, 1 P.M. EST

Asteroid Hebe is at opposition, 7 P.M. EST

New Moon occurs at 10:44 P.M. EST; annular solar eclipse

09 The Moon passes 3° north of Uranus, 5 A.M. EST

10 Neptune is in conjunction with the Sun, 9 P.M. EST

13 The Moon is at perigee (230,043 miles from Earth), 7:56 P.M. EST

13 First Quarter Moon occurs at 10:33 P.M. EST

16 The Moon passes 1.6° north of Mars, 3 A.M. EST

20 The Moon passes 0.7° south of Regulus, 7 P.M. EST

Full Moon occurs at 10:30 P.M. EST; **total lunar eclipse**

21 The Moon passes 3° south of Saturn, 7 A.M. EST

24 Saturn is at opposition, 5 A.M. EST

25 Mercury passes 1.3° north of Venus, 10 P.M. EST

27 The Moon is at apogee (251,309 miles from Earth), 8:27 P.M. EST

28 Last Quarter Moon occurs at 9:18 P.M. EST

The Moon passes 0.6° south of Antares, 10 P.M. EST

WEB EXTRA For definitions of terms, visit www.astronomy.com/glossary.

— *Continued from page 40*

West Coast observers, the Moon rises minutes after the partial eclipse begins, just as the Sun sets. If you're on a hilltop with a clear view of both the western and eastern horizons, you might get a unique opportunity to briefly see both the Sun and eclipsed Moon.

Earth's shadow takes 78 minutes to envelop the Moon completely. Once totality starts, at 10:01 P.M. EST (7:01 P.M. PST), our orbiting companion takes on a reddish-orange hue. The Moon isn't totally dark because sunlight sneaks through Earth's atmosphere, which acts like a lens and bends red rays into the shadow. This bathes the lunar surface in an eerie ruddy light. The shadow's darkness depends largely on the amount of dust in Earth's atmosphere — the more dust, the darker the Moon appears.

As totality progresses and the sky grows darker, the surrounding stars of Leo the Lion pop into view. The constellation's brightest star, Regulus, appears just 3° above the eclipsed Moon.

Meanwhile, Saturn lies 4° to the Moon's lower left. Notice the Moon and Saturn edging closer as the eclipse advances. When the eclipse begins, they lie 4.4° apart; by eclipse end, the gap is down to 3.5°.

Look at the subtle colors across the totally eclipsed Moon. The northern limb should appear darker than the southern limb because it lies deeper in Earth's shadow. Take photographs, either through a telescope or with a camera on a tripod. If you want to capture a wide-field view, try to include interesting foreground objects. And if you get some nice shots, send them to *Astronomy*.

Totality lasts 51 minutes, wrapping up at 10:52 P.M. EST (7:52 P.M. PST). The Moon then leaves the shadow over the following 78 minutes.

Make the effort to see this total lunar eclipse — the next one won't come until December 20/21, 2010.

On February 1, **Mars** stands at the western end of its retrograde loop, situated between Beta (β) and Zeta (ζ) Tauri, the two stars that mark the horns of Taurus the Bull. As February

Martin Ratcliffe *is the author of* State of the Universe 2008 *(Praxis, 2007).* **Alister Ling** *is a meteorologist for Environment Canada.*

SPORADICS TAKE CENTER STAGE

No major meteor shower occurs this month. The background rate of sporadics — those meteors not belonging to a specific shower — averages 5 meteors per hour.

Some suspected minor showers are active in early February, with some swift meteors emanating from Coma Berenices, Leo, and Virgo. While you're watching the waning crescent Moon and the spectacular pairing of planets before dawn, keep an eye out for an occasional streak of light during February's first week.

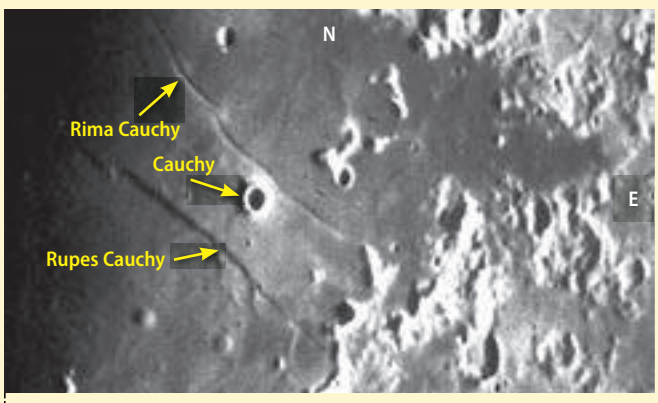
SATURN'S RINGS don't tilt as much to our line of sight this year as they have in the past. This narrow tilt affords observers a better look at the planet's globe. NASA/ESA/THE HUBBLE HERITAGE TEAM (STScI/AURA)

A CRATER SPLITS PARALLEL LINES

On February 10, 4 nights after New Moon, the Sun rises along the eastern shore of Mare Tranquillitatis. Cauchy Crater stands out in the region just north of the lunar terminator's midpoint. (The terminator is the line that divides light from dark on the Moon's surface.) With the Moon at such a young age, however, its dark face should be lit modestly by gray earthshine, sunlight reflected from Earth's dayside.

Cauchy itself is a fairly small crater, some 8 miles across, created when a mini-asteroid slammed into the Moon. The crater's sharp edges mean it formed well after the major bombardment and lava flows ended a few billion years ago.

A prominent rille (Rima Cauchy) lies just north of the crater. This long channel likely formed when an underground lava stream emptied and then collapsed. Eons of tiny impacts have softened its edges. A few days after becoming visible, the rille all but disappears as the higher Sun shines directly into it.



CAUCHY CRATER sports a sharply defined rim, which means the impact that created it occurred well after lava flooded this area in eastern Mare Tranquillitatis. *CONSOLIDATED LUNAR ATLAS*/LPL/UA

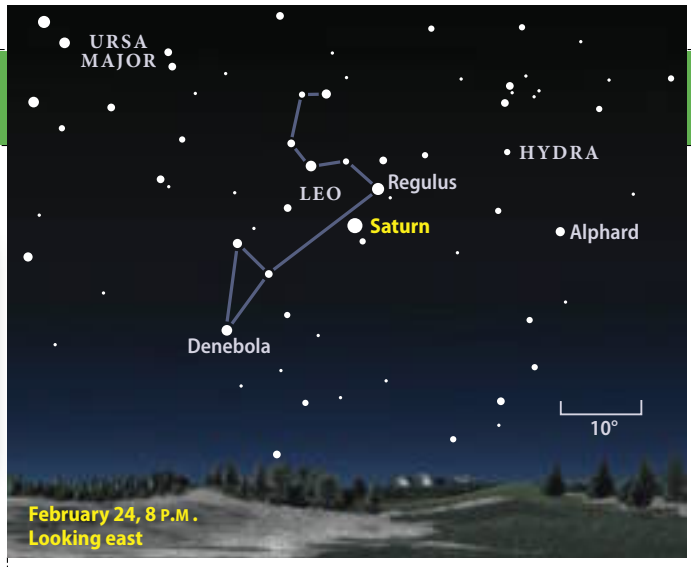
A conspicuous fault scarp (Rupes Cauchy) runs parallel to the rille just south of the crater. Lunar observers consider this fault second only to the famous Straight Wall. At sunrise, the scarp casts a sharp shadow westward, but the dark line disappears a couple of days later.

Two lava domes add interest to this region. When these hills protrude into the advancing sunlight, they create small but noticeable light-dark pairings. The eastern dome, Omega, is likely a shield volcano. The western one, Tau, appears to have formed by uplifting from below.

A late-night treat awaits observers after 2:30 A.M. EST the night of February 18/19. The dark limb of the waxing gibbous Moon snuffs out the bright stars in the core of Cancer's Beehive star cluster (M44) one by one.

/// WHEN TO VIEW THE PLANETS

EVENING SKY	MIDNIGHT	MORNING SKY
Mars (southeast)	Mars (west)	Mercury (east)
Saturn (east)	Saturn (south)	Venus (southeast)
Uranus (west)		Jupiter (southeast)
		Saturn (west)



SATURN REACHES ITS PEAK in February, when it lies opposite the Sun in our sky and remains visible all night. *ASTRONOMY:* JAY SMITH

progresses, Mars' eastward trek gathers pace, and the Red Planet arrives 19° due north of Betelgeuse February 29.

That evening, Mars, Betelgeuse, and Aldebaran form a nearly perfect equilateral triangle of gleaming orange-red objects. They shine at magnitudes 0.2, 0.5, and 0.9, respectively. See if you can spot the brightness differences among this stunning trio.

Red seems to be the sky's predominant color this month. Yet the reasons for the multiple reds vary as much as the objects themselves. The Moon appears red during the total lunar eclipse because dust in Earth's atmosphere scatters sunlight, leaving only the red component to continue to the Moon.

Mars glows red because reddish dust covers its surface and reflects that shade back to Earth. Betelgeuse and Aldebaran produce their own light in the same way the Sun does. They shine red simply because they have relatively low surface temperatures.

Catch Mars early this month — the best part of its apparition is nearing an end. February begins with Mars spanning 12" and shining prominently at magnitude –0.6. By the end of the month, its diameter dips to 9" and its magnitude to 0.2. Still, it remains visible most of the night, setting around 3 A.M. local time on the 29th. With Mars located in Taurus, the planet stands more than 70° high as soon as darkness falls.

Saturn reaches opposition February 24, 3 nights after its close encounter with the eclipsed Moon. This marks the best time of year to view the ringed planet because it lies closest to Earth (771 million miles away), and thus appears biggest and brightest. Opposition also means Saturn is visible all night.

Shortly after the Sun sets, you can see Saturn rising in the

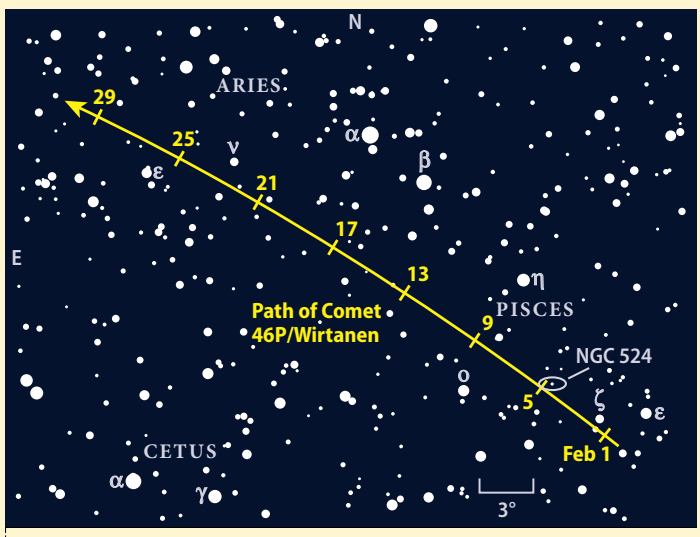
PIN THE TAIL ON THE COMET

Observers with binoculars or a telescope should get good looks this month at Comet 46P/Wirtanen, which rides halfway up the southwestern sky after twilight ends. The best views will come during February's first and last weeks, when moonlight won't interfere with evening observing. You'll need to be under a dark sky to see this comet well.

On February 4 and 5, the dirty snowball shares the same low-power field with the 10th-magnitude spiral galaxy NGC 524. The comet should be a magnitude or so brighter and noticeably bigger. NGC 524 has a bright core and faint halo, while Wirtanen will show a faint tail pointing to the upper left (away from the Sun).

American astronomer Carl Wirtanen discovered this comet 60 years ago. It takes 5.4 years to loop from just outside Earth's orbit to just inside Jupiter's. The giant planet's powerful gravity makes the comet potentially dangerous; Jupiter could modify the icy body's future trajectory into an Earth-crossing orbit.

Astronomers have yet to predict the fate of this interplanetary missile. Wirtanen undergoes numerous close approaches to Earth, Jupiter, Mars, and main-belt asteroids. Additionally, outgassing vents on the comet's nucleus nudge it like uncontrolled retrorockets. These factors combine to make the long-term evolution of Wirtanen's orbit chaotic.



COMET 46P/WIRTANEN should glow at 8th or 9th magnitude in the evening sky. It spends February heading northeast through Pisces and Aries. *ASTRONOMY:* JAY SMITH

While Northern Hemisphere observers enjoy viewing 46P/Wirtanen, those in the Southern Hemisphere can continue to bask in the equally bright return of Comet 8P/Tuttle.

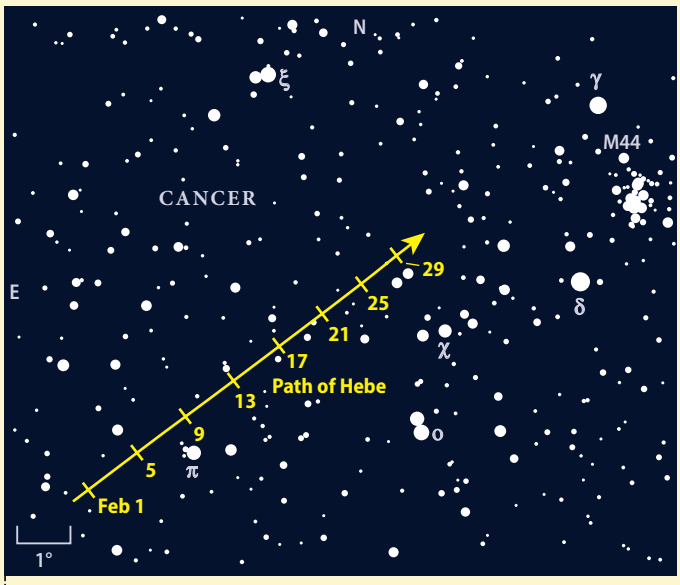
A SHY GODDESS OF YOUTH

The daughter of Zeus and Hera in Greek mythology, Hebe was the embodiment of vigorous youth. She poured the nectar of the gods at the Olympian table. She also lent her name to the sixth asteroid discovered. Prussian amateur astronomer Karl Hencke found this 120-mile-wide space rock in 1847, after 17 years of comparing the positions of the dots of light he saw in his small telescope with those of cataloged stars.

You'll have a much easier time tracking down 6 Hebe, although this goddess will be a little tougher to locate than in a typical hunt. If you wait until the last week of February, Hebe lies about 5° from the Beehive star cluster (M44) in Cancer.

As you star-hop eastward from the Beehive, be sure to stop at the delightfully orange variable star X Cancri. The color of this 6th- to 7th-magnitude star appears striking compared with the usual fare of pale yellows, whites, and blues.

Glowing at 9th magnitude, Hebe travels incognito through star fields containing similarly bright stars. Even if you "go-to" Hebe directly, don't assume the brightest star closest to the field's center is your target. Make a quick sketch of a half-dozen stars and return to the same field a night or two later. The "star" that moved is Hebe. This tried-and-true technique serves as a modern version of Hencke's search method.



ASTEROID HEBE treks slowly through eastern Cancer this month, making a beeline toward the crowded star field of the Beehive star cluster (M44). *ASTRONOMY:* JAY SMITH

east with the stars of Leo. Although early evening is not the best time to turn your telescope on Saturn, just 2 hours later the planet lies 25° high in a dark sky — a decent altitude for low-power viewing. For higher-magnification views (above 100x) or imaging, wait until Saturn climbs at least 45° above the horizon, an altitude it achieves by 10 P.M. in late February.

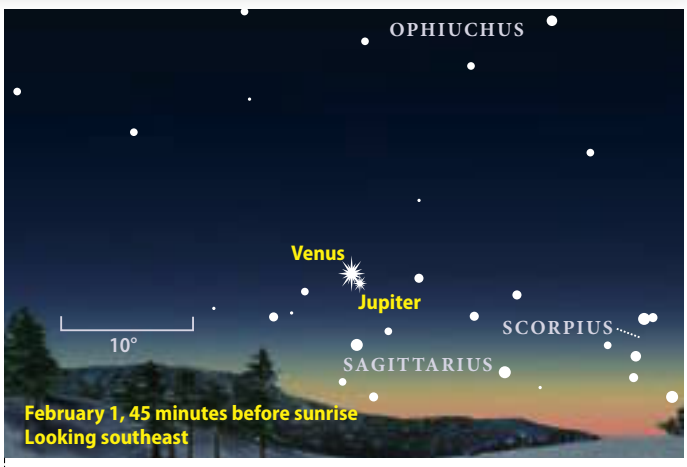
Saturn's disk reaches an apparent diameter of 20" at opposition. The planet's rings more than double this value, spanning 45" east to west. The rings tilt only 8° to our line of sight, however, so they extend just 7" north to south. This slim tilt allows us to see more of the planet's globe.

You also should keep an eye out for unusual arrangements of Saturn's moons. On February 10 and 11, for example, several moons lie close enough together that Saturn's disk could cover them. On the 10th, Iapetus, Tethys, Dione, and Rhea lie within 20" of one another on the planet's western side. The following night, Tethys, Rhea, and Enceladus lie within 13" east of Saturn.

The month's final planetary action occurs just above the southeastern horizon before daybreak. **Venus** and **Jupiter**, the sky's two brightest planets, appear closest to each other February 1. The two rise shortly after 5 A.M. local time (well before the Sun) and lie 35' apart — slightly more than the width of a Full Moon.

Under a dark sky, binoculars will reveal the bright globular star cluster M22 just 2° southeast of Jupiter. Venus shines brilliantly at magnitude –3.9, while Jupiter merely dazzles at magnitude –1.9.

Although they appear close to each other in the sky, Venus is far closer to Earth. It lies 124 million miles away, compared with 562 million miles for Jupiter. Despite its greater distance, Jupiter appears much bigger through a telescope. Its disk spans 33", nearly 3 times larger than Venus' 12" diameter. Venus also displays an 85-percent-lit gibbous phase.



VENUS JOINS JUPITER for a spectacular predawn conjunction in early February. The two brilliant planets rise nearly 2 hours before the Sun. *ASTRONOMY:* JAY SMITH

After the 1st, the two planets appear to separate. Venus falls back toward the Sun while Jupiter pulls away, rising earlier each consecutive morning. The crescent Moon that stands west of Antares February 1 passes 4° south of Venus on the 4th.

As Venus sinks deeper into the twilight in late February, **Mercury** pops into view. The innermost planet passes 1.3° north of Venus February 25/26. Mercury will be difficult to spot then, however, because it's relatively faint and can't punch through the twilight glow as easily.

An **annular solar eclipse** arrives February 7, although few people will see it because the track touches land only in Antarctica. Those in New Zealand, Tasmania, and southeastern Australia will see a partial solar eclipse.

GENUINE LUMICON EQUIPMENT

MADE IN THE USA

ASTRONOMICAL FILTERS
The Most Complete Line of Premium Quality Filters for Astronomy
- Superior Lunar and Planetary Filters - from $19.95
- THE WORLD'S BEST LIGHT POLLUTION & NEBULA FILTERS from $99.95

UNIVERSAL PIER NEW
A sturdy height adjusting mount for Binoculars, Spotting Scopes and Cameras! Provides for comfortable viewing at all angles! $479.95

2" FILTER SELECTOR/DIAGONAL COMBOS NEW
Convert your telescope to a supreme viewing system with Lumicon's renowned line of Diagonals and Filter Selectors! The low profile design of Lumicon Filter Selector/Diagonal Combos allows for perfect use with short refractors and cassegrain telescopes!

- 1.25" & 2" Diagonals from $49.95
- Filter Selectors for Visual and Photographic Use from $129.95
- 2" Filter Selector/Diagonal Combos from $269.95

1.25" C-THREAD ADAPTER NEW
Instant Super-Telephoto! Allows for prime focus photography with video cameras that use C-threads (web cams, etc). Includes 1.25" filter threads. $24.95

DELUXE 80MM SUPERFINDER SYSTEM NEW
Re-engineered for a lighter weight design and sleeker look, the New Lumicon SuperFinder includes a high precision focuser and improved image sharpness! Excellent for guide-scope applications and wide-field astrophotography! Allows for both Straight Though & Right Angle viewing and includes a Custom Carrying Case!

- complete line of Finder Systems - from $199.95

1.25" LOW PROFILE FOCUSER NEW

Let high-precision, smooth focusing bring out the very best in your telescope's optics! The low-profile design quickly and easily converts your standard Newtonian to a camera-ready telescope! Low profile Filter Selector/Focuser Combos also Available!
- Focusers - from $129.95

LASER POINTER SYSTEMS

Quickly aim your telescope at your favorite celestial targets without sacrificing comfort! Includes a quick-release feature for easy transportation and storage! Compatible with reflectors, cassegrains, refractors and Synta dovetail brackets! Available with 5mw Green Laser Pointer! - from $39.95

PARKS EYEPIECES AND BARLOWS NEW
Designed with the latest optical technology and utilizing the finest glass available, Parks premium quality eyepieces and barlows offer reduced color fringing, wider fields of view, less edge distortions, higher contrast images, longer eye relief, and better light baffling than other designs! Includes 1.25" filter threads.

- Eyepieces & Barlows - from $44.95
- Complete Eyepiece & Barlow Kits - from $199.95

OTHER POPULAR LUMICON PRODUCTS:
- Utility Tray Systems for Meade LX Tripods - from $119.95
- Quick Release Finder Brackets from $49.95
- Universal Digital Camera Adapter $49.95
- Visual and Photographic Adapters - from $24.95
- Camera T-Ring Adapters from $19.95
- Step Rings - from $12.95
- Deluxe Piggyback Mounts $64.95
- Focal Reducers - from $79.95
- Easy Guider Photographic Systems - from $199.95
- Sky Vector Computer Systems from $269.95
- Complete Line of Extension Tubes and Adapters - from $24.95
- Vinyl Dust Covers & Plugs from $8.95
- Lens Cleaning Equipment from $3.95

LUMICON INTERNATIONAL
750 Easy Street
Simi Valley, CA 93065
US 800.420.0255
805.520.0047
WWW.LUMICON.COM

THERE IS NO SUBSTITUTE! LUMICON

ATOMIC TIME

1010 Jorie Blvd. #332
Oak Brook, Il 60523
1-800-985-8463
www.atomictime.com

14" LaCrosse Black Wall
WT-3143A $21.45
This wall clock is great for an office, school, or home. It has a professional look, along with professional reliability. Features easy time zone buttons, just set the zone and go! Runs on 1 AA battery and has a safe plastic lens.

Digital Chronograph Watch
ADWA101 $49.95
Our feature packed Chrono-Alarm watch is now available for under $50! It has date and time alarms, stopwatch backlight, UTC time, and much more!

LaCrosse Digital Alarm
WS-8248U-A $49.95
This deluxe wall/desk clock features 4" tall easy to read digits. It also shows temperature, humidity, moon phase, month, day, and date. Also included is a remote thermometer for reading the outside temperature on the main unit. approx. 12" x 12" x 1.5"

1-800-985-8463
www.atomictime.com
Quantity discounts available!

LaCrosse WT-5720UU Clock $24.95
This digital projection clock is great for travel and fits in a small space. Shows 12 or 24 hour time, time zone, and alarm time. Size 5.25"x 1.25"x 4"

Tell time by the U.S. Atomic Clock -The official U.S. time that governs ship movements, radio stations, space flights, and warplanes. With small radio receivers hidden inside our timepieces, they automatically synchronize to the U.S. Atomic Clock (which measures each second of time as 9,192,631,770 vibrations of a cesium 133 atom in a vacuum) and give time which is accurate to approx. 1 second every million years. Our timepieces even account automatically for daylight saving time, leap years, and leap seconds. $7.95 Shipping & Handling via UPS. (Rush available at additional cost) Call M-F 9-5 CST for our free catalog.

DISCOVER
Kitt Peak
NATIONAL OBSERVATORY
Tucson, AZ

Public Programs for Amateur Astronomers
- CCD Workshops
- Digital camera imaging
- CCD imaging with our expert guides
- Astrophotography
- or just observe

520-318-8726
www.noao.edu

How Your Brain Works

Look Inside This Astonishingly Complex Organ with One of the Most Effective Teachers in America

Everything you hear, feel, see, and think is controlled by your brain. It allows you to cope masterfully with your everyday environment, and is capable of producing breathtaking athletic feats, sublime works of art, and profound scientific insights. But its most amazing achievement may be that it can understand itself.

Understanding the Brain takes you inside this astonishingly complex organ to show you how it works. Recent decades have seen unparalleled advances in understanding how the brain does what it does. Today we can pinpoint the specific regions where some of life's most mysterious processes take place.

You will share Professor Jeanette Norden's consuming passion in these 36 lively lectures, which Professor Norden has designed specifically for those without a background in science. "All you need to bring is your own brain and a desire to learn," she says.

Our endogenous reward system is considered responsible for the internal positive feelings we experience when engaging in activities as diverse as interacting with friends, reading a good book, or viewing a sunset. People who enjoy learning have these areas stimulated when they take a course such as this one—so reward yourself! Our brains are incredibly plastic, which means that we continue to learn from our experiences at any age in ways that enrich our lives.

About Your Professor

Dr. Jeanette Norden is a neuroscientist, Professor of Cell and Developmental Biology in the School of Medicine, and Professor of Neurosciences in the College of Arts and Sciences at Vanderbilt University. Dr. Norden has won numerous university and national teaching awards and was the first recipient of the Chair of Teaching Excellence at Vanderbilt.

About The Teaching Company

We review hundreds of top-rated professors from America's best colleges and universities each year. From this extraordinary group, we choose only those rated highest by panels of our customers. Fewer than 10% of these world-class scholar-teachers are selected to make The Great Courses.

We've been doing this since 1990, producing more than 3,000 hours of material in modern and ancient history, philosophy, literature, fine arts, the sciences, and mathematics for intelligent, engaged, adult lifelong learners. If a course is ever less than completely satisfying, you may exchange it for another, or we will refund your money promptly.

About Our Sale Price Policy

Why is the sale price for this course so much lower than its standard price? Every course we make goes on sale at least once a year. Producing large quantities of only the sale courses keeps costs down and allows us to pass the savings on to you. This also enables us to fill your order immediately: 99% of all orders placed by 2 pm eastern time ship that same day. Order before February 29, 2008, to receive these savings.

© Images.com/Corbis.

Lecture Titles

1. Historical Underpinnings of Neuroscience
2. Central Nervous System—Gross Organization
3. Central Nervous System—Internal Organization
4. Central Nervous System—Subdivisions
5. Cortex—Lobes and Areas
6. Cortex—Sensory, Motor, and Association Areas
7. Central Nervous System—Development
8. Central Nervous System—Cellular Organization
9. Pathways and Synapses
10. Neurotransmitters
11. Stroke
12. The Visual System—The Eye
13. The Visual System—The Cortex
14. The Auditory System
15. The Somatosensory System
16. Agnosias
17. The Motor System—Voluntary Movement
18. The Motor System—Coordinated Movement
19. Parkinson's Disease
20. Language
21. The Limbic System—Anatomy
22. The Limbic System—Biochemistry
23. Depression
24. The Reward System—Anatomy
25. The Reward System—Drugs
26. Brain Plasticity
27. Emotion and Executive Function
28. Processing of Negative Emotions—Fear
29. Music and the Brain
30. Sexual Dimorphism of the Brain
31. Sleep and Dreaming
32. Consciousness and the Self
33. Alzheimer's Disease
34. Risk Factors for Alzheimer's Disease
35. Wellness and the Brain—Effects of Stress
36. Neuroscience—Looking Back and Looking Ahead

Please Note: These lectures are in no way designed to be used as medical references for the diagnosis or treatment of medical illnesses or trauma. Questions of diagnosis or treatment of medical conditions should be brought to the attention of qualified medical personnel.

THE TEACHING COMPANY®
The Joy of Lifelong Learning Every Day™
GREAT PROFESSORS, GREAT COURSES, GREAT VALUE GUARANTEED.™

SAVE $275!
OFFER GOOD UNTIL FEBRUARY 29, 2008

1-800-TEACH-12 (1-800-832-2412)
Fax: 703-378-3819

Special offer is available online at
www.TEACH12.com/7astr

The Great Courses
THE TEACHING COMPANY
4151 Lafayette Center Drive, Suite 100
Chantilly, VA 20151-1232

Priority Code 26325

Please send me **Understanding the Brain**, which consists of thirty-six 30-minute lectures and Course Guidebooks.

☐ **DVD $99.95** (std. price $374.95) **SAVE $275!**
plus $15 shipping, processing, and lifetime satisfaction guarantee..

☐ **Check or Money Order Enclosed**

* Non-U.S. Orders: Additional shipping charges apply.
For more details, call us or visit the FAQ page on our website.
** Virginia residents please add 5% sales tax.

Charge my credit card:

☐ VISA ☐ ☐ ☐

ACCOUNT NUMBER EXP. DATE

SIGNATURE

NAME (PLEASE PRINT)

MAILING ADDRESS

CITY/STATE/ZIP

PHONE *(If we have questions regarding your order—required for international orders)*

☐ **FREE CATALOG.** Please send me a free copy of your current catalog (no purchase necessary).

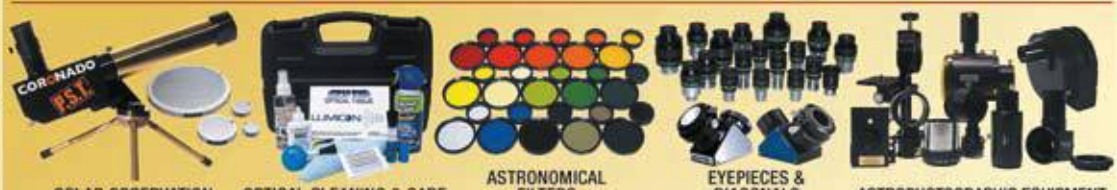
Special offer is available online at www.TEACH12.com/7astr
Offer Good Through: February 29, 2008

NEED ASTRO EQUIPMENT?

EXPERT HELP • 800.235.3344

CELESTRON · PARKS · LUMICON · TeleVue · MEADE · JMI · SBIG · LOSMANDY · STELLARVUE · Vixen · CORONADO · Thousand Oaks Optical · ZEISS · WILLIAM OPTICS · Kowa · Canon · Nikon · KONUS · FUJINON · Starry Night · KENDRICK ASTRO INSTRUMENTS

ASTRONOMICAL TELESCOPES · ASTRONOMICAL BINOCULARS · COMPUTER SOFTWARE · BOOKS & STAR CHARTS



SOLAR OBSERVATION · OPTICAL CLEANING & CARE · ASTRONOMICAL FILTERS · EYEPIECES & DIAGONALS · ASTROPHOTOGRAPHIC EQUIPMENT

For All Major Brands at Discount Prices, Visit SCOPECITY.COM, Any Scope City Center or Call Us Directly 800.235.3344

• SIMI VALLEY, CA - 805.522.6646 • COSTA MESA, CA - 714.957.6900 • SAN FRANCISCO, CA - 415.421.8800
• SHERMAN OAKS, CA - 818.789.5805 • SAN DIEGO, CA - 858.277.6686 • LAS VEGAS, NV - 702.947.2673

GIFT CERTIFICATES AVAILABLE

Scope City

SAVE UP TO 40%

THE LARGEST AND MOST COMPLETE OPTICAL CENTERS IN THE WORLD

WOnline (WILLIAM OPTICS)

www.williamoptics.com

Ferrari ZenithStar and Ferrari Visio: www.williamopticsracing.com

William Optics Member Program - look for details.

Best Buy!

Quartz DIG 2 + UWAN 4mm

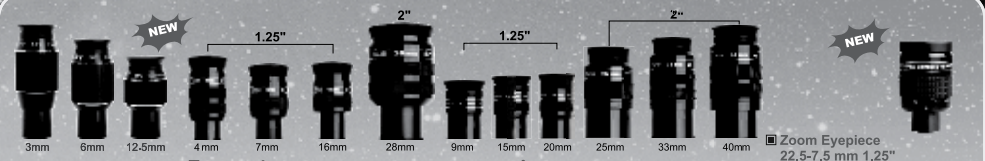
~~$ 1,598~~ **$ 1,298**

Megrez 90

The Best Value of 90mm APO Scope you can find on the Market! Package included the following items, M90FD OTA+ 2" Quartz Dielectric diagonal (99% reflective rate! + UWAN 4 mm eyepiece.)

New Year Super Saving Package

2008



▣ SPL Eyepieces — Planetary eyepieces with long eyerelief 20mm. SUPER PRICE

▣ UWAN 82° Ultra Wide Field Eyepieces — Ideal for fast telescopes and for those who want the best-corrected and widest FOV ! SUPER PRICE

▣ SWAN 72° Super Wide Field Eyepieces — Ideal for SCT refractors users ! SUPER PRICE

▣ Zoom Eyepiece 22.5-7.5 mm 1.25" — New W.O. Zoom Eyepiece, Wide Angle 66deg.; a super eyepiece at a price everyone can afford! ~~$ 268~~ $ 228

▣ 2" Quartz Dielectric Diagonal — ~~$ 268~~

▣ 90" degree Erecting Prism — ~~$ 248~~

▣ 2" & 1.25" Carbon Fiber Diagonal — FROM $ 79

▣ 2" 45° degree Erecting Prism — ~~$ 198~~

▣ 1.25" 45° degree Erecting Prism with 2" Barrel — ~~$ 88~~

▣ Binoviewers — Find out why two-eye views are so much better ! (OTA or package) ~~$ 499~~

▣ 2" SCT Crayford Focuser 2 speed — ~~$ 199~~

▣ Most brand compatible Dovetail Fully anodized — Fully anodized machined plate, fits Vixen mounts and Synta mounts, and other compatible mounts. ~~$ 88~~

▣ DCL-52 Digital Camera & video adapter — $ 109

▣ Reducer 0.8x Field Flattener II — Ideal for ZS 66 SD and similar refractors, 2" nosepiece and SCT adapter. $ 148

▣ Reducer 0.8x Field Flattener III — Recommended for users of our Megrez 80, 90 and 110. $ 199

▣ 6x30 Erecting Finder Scope — $ 79

▣ Astrophoto Package — · 2" APO Barlow · 2" Photo Adapter · 2" Extender · 2" APO 0.8x reducer / flattener · 3 1.25" SWAN eyepieces · Soft Carrying case $ 449

USA Toll Free: +1-866-918-6888 E-mail: wo@williamoptics.com Tel: +1-714-898-7989

Free Shipping for Most WO products !
Promotion Code: WOFS1207
expires on: Jan. 31st, 2008

(Promotion Code must be surrendered at the time of purchase. Standard Ground Free shipping offer does not include Ferrari products nor paypal transactions. may not be combined with other promotional package offers or discount or applied to previous order. This offer is only for USA customer, Canada customer call for detail)

Why you're better off buying telescope accessories at OPT!

FREE SHIPPING!

- ✓ Better Product Knowledge
- ✓ CompetitivE ic g
- ✓ Greater Variety
- ✓ OPT Rewards
- ✓ FREE Shipping (12/26/07-1/10/08)

CELESTRON
Astronomy made simple!

MEADE
Experience you can trust!

TeleVue Visionary
The world's best ey7pieces!

SBIG
The leader in CCD imaging!

Craig Weatherwax, "The Don" and Founder of OPT

Featuring:
Astrodon • Astronomik • Baader • JMI • Kendrick • Losmandy
OPT • Pentax • Stellarvue • Takahashi • Vixen • William Optics

New at OPT:
APM Telescopes • ASA Telescopes • QSI • The Imaging Source • AstroTrac

Also: ADM, Antares, Astro Systems, A Zg , As rovid, Bob's Knobs, Borg, BT T
Canon, ChronosMount, Coronado, Custom Scientific, Denkmeier, FLI, Green Lasers,
Hu ech, Lumicon, Lumenera, Lymax, Maxfactory, MaximDL, MitE , NE ong Opt c, Ori
Parallax, Peterson Engineering, Phillips, Pier-Tech, QSI, RC Optical, Rigel Systems,
ScopeGuard, Sirius Technology, Software Bisque, S larScope, Starbound, StarGPS, Starlight
Instruments, StarryNight, Telegizmos, Telrad, Unihedron, Vector, and Yankee Robotics

OPT
optcorp.com
800.483.6287
For Binoculars visit www.optbinoculars.com

THE ULTIMATE IN ASTRO SHOPPING:
www.adorama.com

PREMIER SELECT CELESTRON DEALER

CPC Series
XLT Starbright H.P. Schmidt Cassegrain Telescope with NexStar Computer Control & SkyAlign Technology

Tomorrow's next generation 8, 9.25, and 11 computerized GPS SCT's are here now!

NexStar SE

NEW! Nexstar SE Series ***4SE, 5SE, 6SE, 8SE,***
INCLUDES:
- XLT Coatings
- Orange Removable OTA,
- 40,000 object database,
- Nexstar Remote Software,
- The Sky Software
- Adjustable Tripod

SkyAlign

STARTING AT $599.00

CGE-1400, 14" Schmidt-Cassegrain Telescope with XLT Coatings & CGE German Equatorial Mount

- 14" (356mm) Schmidt-Cassegrain Optical Design
- 3910mm Focal Length, f/11
- StarBright Multi-Coating
- XLT Coating Optional
- Computerized Equatorial Mount
- 40,000+ object database with 400 user-defined objects. CompassCalibration, Polar Alignment routine, Auto North and Level, Quick Align.
- Super HD Tripod
- Computerized Hand Control
- RS-232 communication port on hand control
- Optical Tube Weight - 45 lb.
- Tripod/Mount Weight - 139 lb.

CELESTRON TELESCOPE ACCESSORIES

NexImage
Solar System Imager
NEXIMAGE ACCESSORIES
UV/IR CUT OFF Filter 52.95
Neximage Reducer 21.95
2x Ultima Barlow Lens.....60.95

$99.95

EYEPIECES KITS

Includes: • 5 Superior Grade Plossl Eyepieces 1.25"(4mm, 6mm, 9mm, 15mm, & 32mm), • 2x Barlow Lens, • Six Colored Filters, • Moon Filter, • Aluminum Carrying Case
All for only $129.95

2" ACCESSORY KIT
Includes: • 3-2" Eyepieces, 2" 5 Color Filters, 2"Star Dia, 2" 2X Barlow Aluminum Case $239.95

BINOCULARS

25 x 100 SkyMaster, Weather Resistant Porro Prism Binocular with 3.0 Degree Angle of View, U.S.A.
- Waterproof
- BAK-4 Porro
- Multicoated Optics
- Long eye Relief
- Integrated Tripod Adapter
- Structural reinforcement of the main body for maximum stability

Celestron No Fault Limited Lifetime warranty

CELESTRON SKYSCOUT

SKYSCOUT PERSONAL PLANETARIUM

Introducing the SkyScout from Celestron:
The SkyScout is a revolutionary, one of a kind, patented handheld device that instantly identifies and/or locates any celestial object visible to the naked eye, providing educational and entertaining information, both in text and audio.

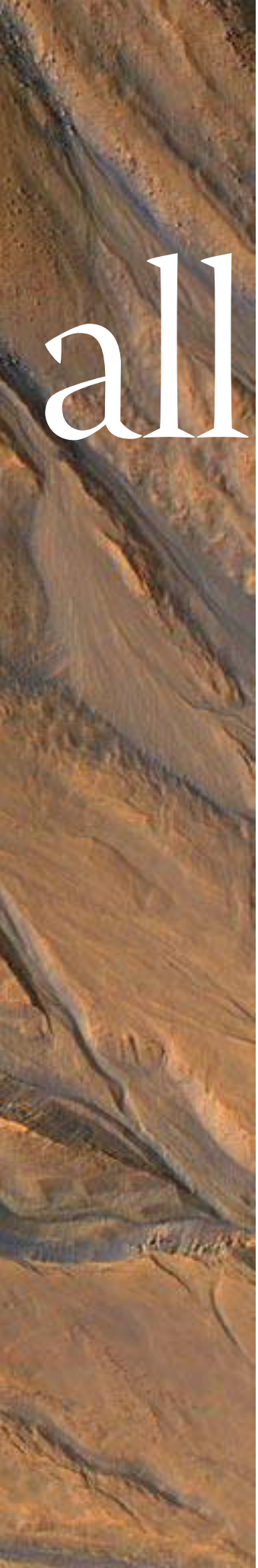
A fun learning tool for all ages, the SkyScout personal planetarium puts the knowledge of an expert astronomer in the palm of your hand.

Item Includes: Carry Case, Earphones, Hand Strap, USB Cable

$399.95

ADORAMA INC.
Source for the Educated Photographer

WATER-CARVED GULLIES cut through the rocky cliffs near the rim of this martian crater in the southern highlands. The boulder-strewn, braided channels meander down the slope, offering some of the best evidence that fluids once flowed on Mars. ALL IMAGES: NASA/JPL/UNIVERSITY OF ARIZONA



Where has all the water gone?

New results from Mars Reconnaissance Orbiter suggest the Red Planet's past may not have been so warm and wet after all.

/// BY RICHARD TALCOTT

If the solar system were a giant amusement park, Mars would have to be its biggest, baddest roller coaster. For more than a century now, the Red Planet has been taking planetary scientists for a wild ride. Was Mars' climate once warm and wet or cold and dry? And does liquid water play any role on the martian surface today?

If you didn't like the prevailing trend of scientific thought, you usually didn't have to wait long for it to change. Now, as 2007 turns to 2008, the coaster's track seems to be veering back toward a cooler, drier past — and a present with little or no liquid water.

In most cases, new spacecraft drove the change. The first Mariner spacecraft in the mid-1960s destroyed the idea of a lush planet popularized by Percival Lowell. The bone-dry, crater-pocked, and lifeless surface that replaced Lowell's vision lasted only a few years. Mariner 9 and the Viking missions pulled the roller coaster back up the "hill of water," where most scientists have remained.

Richard Talcott *is a senior editor of* Astronomy.

Now, the latest spacecraft — Mars Reconnaissance Orbiter (MRO) — has found some of the evidence for past and present water doesn't pass closer scrutiny. MRO's High-Resolution Imaging Science Experiment (HiRISE) can see details as small as a couple of feet (0.5 meter) across, fine enough to reveal small boulders.

HiRISE scientists, led by principal investigator Alfred McEwen of the University of Arizona, studied two fresh deposits of bright material located in martian gullies. Just a year ago, researchers found these deposits in images taken by the Mars Global Surveyor (MGS) spacecraft where earlier images showed nothing.

"The key question raised by these two deposits is whether water is coming to the surface of Mars today," says McEwen. Although the MGS team answered "yes," MRO scientists aren't so sure. "Our evidence suggests the new deposits did not necessarily involve water," says McEwen.

HiRISE images show these and four other similar-looking deposits all occur on slopes greater than 20°. That's close to the limit at which dry, loose debris remains stable, raising

NORTH POLAR LAYERED DEPOSITS record the changing martian climate. The lighter, ice-rich layers — formed during periods of more stable climate — alternate with darker, sandy strata. The layers here are only about 4 inches (10cm) thick.

ATHABASCA VALLES, Mars' youngest outflow channel, likely formed during a catastrophic flood. However, MRO images show a thin veneer of lava covers the dusty region. Blue in this image reveals slopes too steep for dust to accumulate.

the distinct possibility the deposits formed during landslides. Observations made by MRO's Compact Reconnaissance Infrared Spectrometer confirm the deposits are not frost or ice.

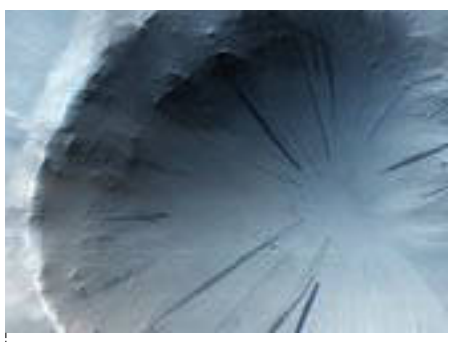
Landslides also may produce the dark streaks seen on the interior slopes of some impact craters. Frank Chuang of the Planetary Science Institute in Tucson leads a team looking at these streaks, which some previous researchers believed could be signs of water. HiRISE images taken when the Sun was low in the sky show the features are not flat. The team concludes avalanches of dry dust created the streaks.

Other gullies, however, show braided channels and terraces that look eerily similar to water-carved features on Earth — and at slopes less than 20°. This implies liquid water flowed through the gullies sometime in the past few million years. Perhaps they formed during a warmer climate cycle, when periodic changes in Mars' orbit and axial tilt made the climate more hospitable to liquid water.

A record of these climate changes exists in layered deposits at both the north and south poles. Kenneth Herkenhoff of the U.S. Geological Survey in Flagstaff, Arizona, and his colleagues imaged the north polar deposits with HiRISE. They found layers as thin as 4 inches (10 centimeters), but dust in some spots may hide finer layers. The alternating deposits likely arose under different climates: The darker, sand-rich layers formed when the planet's axis tilted more toward the Sun and ice couldn't build up at the pole, while the brighter layers of ice and dust formed during periods when lots of ice accumulated.

Layers of a different kind cover Athabasca Valles. These valleys — the youngest outflow channel system on Mars — seemed a sure-fire creation of flowing water. But Windy Jaeger of the U.S. Geological Survey and her team used HiRISE images and found a thin layer of solidified lava covers the whole region.

The lava apparently erupted from a fissure in Cerberus Fossae, then inundated Athabasca Valles before flowing into the Cerberus Palus basin. Although lava now covers the region, both Jaeger and McEwen



DARK STREAKS up to a thousand feet (300m) wide and several miles long cascade down the slopes of this impact crater in Terra Sabaea. MRO images show the streaks formed in avalanches of dry dust, not from flowing liquids.

SALT DEPOSITS in this unnamed crater located in Terra Cimmeria probably represent the remains of a lake that evaporated early in Mars' history.

MASSIVE BOULDERS at least a couple of feet (0.5m) wide litter the northern lowlands. Scientists originally thought these lowlands were the site of an ancient ocean, but the boulders argue otherwise.

still think water carved this channel system. Similar lava eruptions could explain why every Mars lander sent to explore scenes of ancient floods has found mostly lava instead.

Despite the likelihood of flowing water at some point in Mars' past, the existence of an ancient ocean now seems unlikely. Some scientists thought water once filled the vast northern lowlands. When it evaporated, the ocean would have left behind deposits of sand-grain-sized sediments up to several hundred feet (100m) deep. But HiRISE images reveal boulders strewn throughout the lowlands. Either the sediments were far thinner than anyone expected, or the ocean never existed.

Smaller bodies of water almost certainly survived on the ancient martian surface, however. Scientists from MRO, MGS, and Mars Odyssey spacecraft have found regions in the heavily cratered highlands of the southern hemisphere covered with salts. The researchers believe water in ancient lakes deposited these salts as the lakes evaporated.

THE MARS SCIENCE LABORATORY likely will land in one of a half-dozen spots scientists recently selected. This shows one of those regions, in the Nili Fossae trough.

Sites created by water — and the possible life it may have spawned — remain prime targets for planetary scientists. Last October, researchers met in Pasadena, California, to narrow down potential landing sites for NASA's Mars Science Laboratory (MSL) rover. The mission, set to reach Mars in 2010, will try to determine if Mars ever was habitable — and whether it might still be.

Using HiRISE images as one resource, the scientists whittled a list of 51 candidate sites down to six high-priority ones: the Nili Fossae trough, Mawrth Vallis, southwestern Meridiani Terra, Jezero Crater, Holden Crater, and Terby Crater. The scientists decided four other sites need further study. MRO will continue examining the chosen sites during the next several months, and NASA will make its final selection by October.

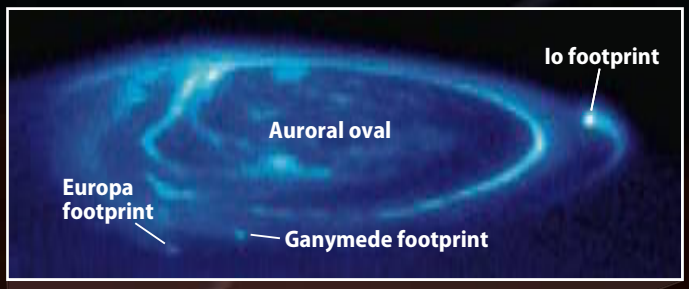
No one knows whether MSL or other missions will dramatically change the course of the martian roller coaster once again. But we had best keep our grip on the safety bar for what promises to be a bumpy ride.

WEB EXTRA To see more great MRO images, visit www.Astronomy.com/toc.

Explore Jupiter's moons

Tenuous dust rings, glowing gas clouds, and a ring of plasma arise from Jupiter's closest moons. /// BY FRANCIS REDDY; ILLUSTRATION BY ROEN KELLY

There's more than gravity at work between Jupiter and its closest moons. Scientists think the innermost satellites — named Metis, Adrastea, Amalthea, and Thebe — are rubble-pile asteroids. Impacts easily blast dust off the moons' surfaces. This process creates and sustains Jupiter's delicate rings.



CURRENTS FLOWING along the Io flux tube produce a 100-million-watt auroral "footprint" in Jupiter's polar atmosphere. Dimmer spots arise from Ganymede and Europa, which produce weaker currents.

Jupiter's "big four" moons — Io, Europa, Ganymede, and Callisto — come next. Callisto is a battered ice ball nearly as big as the planet Mercury; it may host a layer of briny water beneath its crust. But Europa does it one better. Many scientists believe Europa's icy surface caps a global ocean. Between them lies Ganymede, the solar system's largest moon. Ganymede is bigger than Mercury and even generates its own magnetic field.

And then there's Io, the closest of Jupiter's four major moons. Io's response to gravitational tugs from neighboring Europa and Ganymede let Jupiter raise tides on Io. These tides heat the moon's interior into a brew of molten rock and sulfur that pours onto the surface through volcanos. Io literally is turning itself inside out.

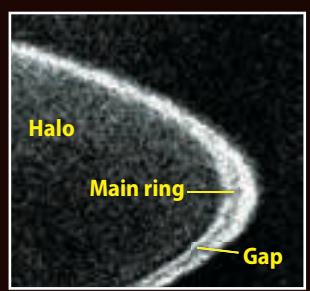
Sunlight ionizes sulfur and oxygen in eruption plumes, and Jupiter's intense magnetic field sweeps the ions around the moon's orbit. Some of these particles strike Io's back side, ejecting a ton of sodium atoms each second. Scientists can detect this sodium cloud at 100 times Io's distance from the planet.

Most surprisingly, these colliding ions drive an intense current between moon and planet. Something similar happens at Europa and Ganymede, too. All three moons throw auroral spotlights onto Jupiter's poles.

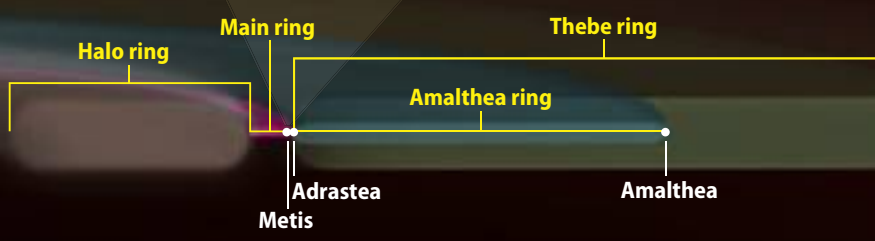
Jupiter to Io

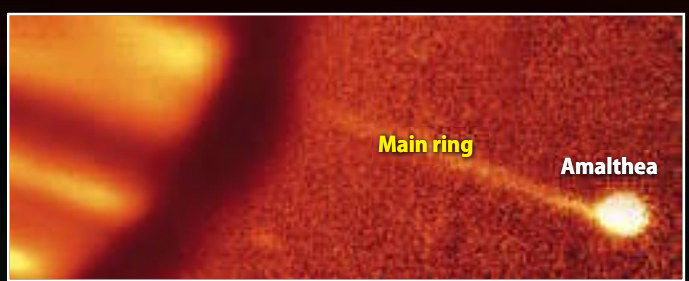
▼ THIS PLOT shows Jupiter's ghostly rings, its innermost moons, and the strange phenomena driven by its volcanic moon Io.

Rings are labeled in yellow.
Moons are labeled in white.



NASA'S NEW HORIZONS probe found a gap in the main ring during its 2007 flyby. This may be caused by an unknown moon.





JUPITER'S MAIN RING glows dimly in this infrared image from the Subaru Telescope in Hawaii.

0 5,000 10,000 miles
0 10,000 20,000 km

Astronomy magazine

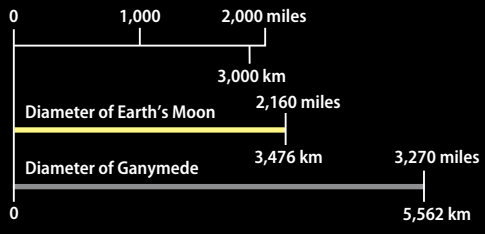
Jupiter's inner moons

Io
The solar system's most volcanic body; 5 percent larger than Earth's Moon

Europa
Possibly supports an ocean beneath an icy crust; 90 percent the size of Earth's Moon

Ganymede
The solar system's largest satellite; 8 percent larger than the planet Mercury

Callisto
The solar system's third largest moon; 1 percent smaller than Mercury



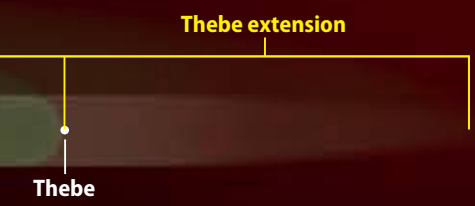
Magnified 5 times

The moons' red color may be caused by sulfurous debris from Io's eruptions.

Galilean moons

IN 1610, GALILEO discovered Jupiter's four largest moons.

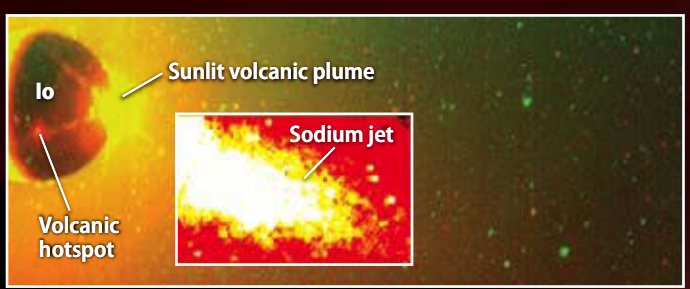
IO'S ATMOSPHERE glows with aurorae when the moon passes into Jupiter's shadow. Electrical currents make oxygen (red), sodium (green), and sulfur dioxide (blue) gases emit light.



Io's neutral sodium cloud
A dimly glowing cloud of uncharged sodium atoms surrounds Io.

Io's plasma torus
Jupiter's magnetic field spins 4 times faster than Io orbits the planet. The field sweeps ionized sulfur and oxygen into a doughnut-shaped cloud (red) around Io's orbit.

Io's flux tube
The flux tube associated with Io channels nearly 3 million amps of electricity between the moon and Jupiter. Charged particles trapped in Jupiter's magnetic field strike Io from behind. This creates a 400,000-volt difference across the moon's leading and trailing sides and powers the current.



THE GALILEO MISSION imaged Io and its sodium cloud in 1996. Extra processing (inset) reveals a jet of sodium atoms exiting Io's night side.

METIS, ADRASTEA, AMALTHEA, THEBE IMAGES: NASA/JPL/CORNELL UNIVERSITY; IO, EUROPA, GANYMEDE, CALLISTO: NASA/JPL/GERMAN AEROSPACE CENTER; JUPITER: NASA/JPL/SPACE SCIENCE INSTITUTE; JUPITER AURORAE: NASA/ESA/JOHN CLARKE (UNIV. OF MICHIGAN); MAIN RING: NASA/JHUAPL/SwRI; JUPITER AND AMALTHEA: SUBARU TELESCOPE/NAOJ; IO AURORAE: NASA/JPL/PIRL/UNIV. OF ARIZONA; IO SODIUM JET: NASA/JPL/MATTHEW H. BURGER ET AL. 1999

ASK ASTRO

This month:
- Do photographs of Mars show change over time?
- Do black holes swallow neutrinos?
- Why do neutron stars have small diameters?
- Are galaxies expanding apart or moving toward each other?

MARS CHANGES

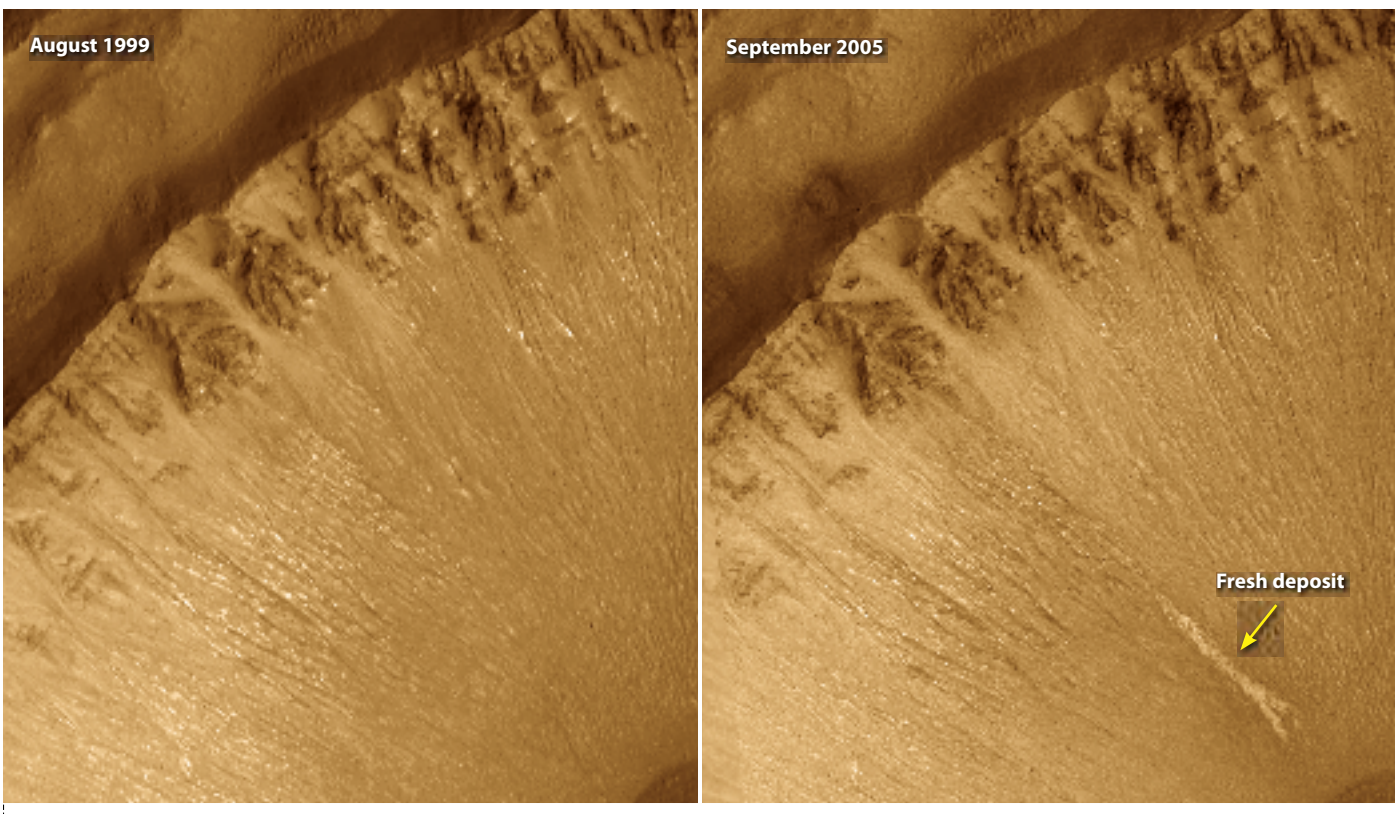
Q: Do any two photos taken of the same location on Mars at two different times show surface changes? — **BOB FANDRICH,** PALM BAY, FLORIDA

A: Scientists analyzing the hundreds of thousands of images of Mars' surface have seen evidence of changes with time. At the telescopic scale, we've seen the famous dark markings of Mars change over the decades, as windblown dust moves across dark volcanic rocks and sand. At the best telescopic resolutions (like from the Hubble Space Telescope) and from orbital weather-satellite-like cameras, we've also seen changes in brightness due to surface dust, clouds of dust, and water ice. These features come and go in what are becoming predictable patterns of martian weather. At the highest resolution from cameras on orbiters and landers/rovers on the martian surface, we've seen other kinds of surface changes occurring over days to months to years.

Examples from more than 4 martian years of high-resolution photos from the Mars Orbiter Camera on the Mars Global Surveyor spacecraft include the appearance of new dark "slope streaks," several hundred meters or more long, on the walls of some craters and ridges. The streaks probably formed by the down-slope movement of sand or dust, and the development of new pits and cracks in the polar caps.

Astronomers have observed no changes on Mars' surface attributable to active marsquakes or active surface or subsurface volcanic activity. However, the tiny landslides seen in lander/rover images could have been triggered by marsquakes, but we have no way of knowing if that's the case (there are no seismic networks on Mars as there are on Earth).

There are other possible explanations for what triggers these events. For example, additional dust falling out of the atmosphere



A CHANGING MARS is visible in these two images. Taken in August 1999 (left) and September 2005, the images show changes to an unnamed crater in Mars' Centauri Montes region. NASA's Mars Global Surveyor took the images, which show a fresh deposit scientists believe formed when liquid water briefly flowed on the surface.

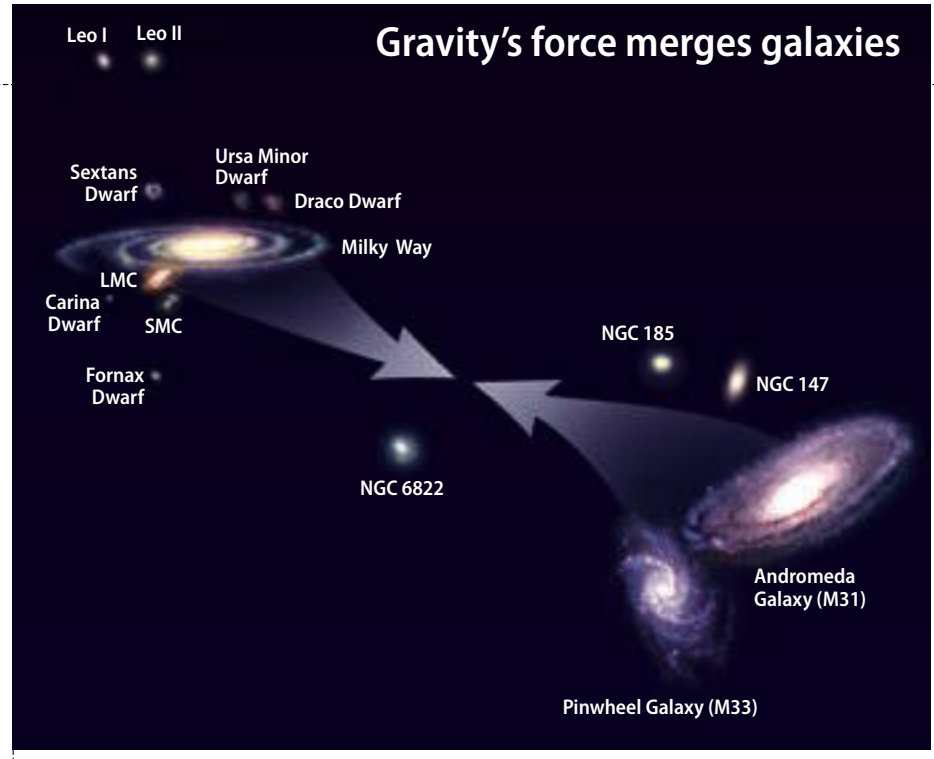
may push surfaces on the brink of collapsing past their limits. — **JIM BELL,** CORNELL UNIVERSITY, ITHACA, NEW YORK

ELUSIVE NEUTRINOS

Q: Does a black hole gobble up neutrinos, or do the neutrinos just breeze through the black hole as they do through everything else? — **HUGH CEDRIC,** BEIJING

A: Neutrinos are among the most ghostly particles. Because these neutral particles are unaffected by electric fields, it is commonly cited that they could pass through a block of lead 50 light-years thick and emerge unmolested.

But, despite their fantastic abilities, neutrinos consist of normal matter and must succumb to a black hole's pull. No particle known can avoid gravity. — **SIMON DEDEO,** KAVLI INSTITUTE FOR COSMOLOGICAL PHYSICS, UNIVERSITY OF CHICAGO



THE MILKY WAY and Andromeda galaxies will one day collide despite the fact that space-time itself is expanding. That's because local gravity overpowers the expansion and pulls these galaxies toward one another. *ASTRONOMY:* ROEN KELLY

SIZE LIMIT

Q: Why are neutron stars constrained to a diameter of 10 to 12 miles? — **JACK WHITMAN,** PHILADELPHIA

A: Neutron stars form from stars with masses above roughly 1.4 times our Sun's mass. Below that mass, stars will end their lives as white dwarfs, which are larger than neutron stars.

If we could make a black hole of 1.4 solar-masses, its event horizon would be 2.4 miles (3.9 km) across. So, a neutron star must be larger than that because if it were compressed below 2.4 miles wide, it would become a black hole.

A neutron star has a density roughly equal to that of an atomic nucleus. At this density, 1.4 solar-masses of matter must be about 12 miles (20 km) across. — **SIMON DEDEO,** KAVLI INSTITUTE FOR COSMOLOGICAL PHYSICS, UNIVERSITY OF CHICAGO

IN THE KNOW

MARSQUAKE
An earthquake on Mars.

NEUTRINO
A subatomic particle produced in a nuclear reaction; neutrinos have no electrical charge, travel at close to the speed of light, and rarely interact with matter.

NEUTRON STAR
The collapsed, extraordinarily dense, city-sized remnant of a high-mass star.

SPACE-TIME
The combination of the three dimensions of space with one dimension of time within which events can be specified exactly.

EXPANDING GALAXIES

Q: If galaxies are expanding away from one another, why are Local Group galaxies like the Milky Way and Andromeda moving toward each other? — **ROBYN NAYYAR,** AROMAS, CALIFORNIA

A: Local gravity overpowers cosmological expansion.

The cosmological "motion" of galaxies away from each other is due to the stretching of space-time, which carries the galaxies along, rather than to the motion of the galaxies themselves as they move through space. Think of the galaxies as dots painted on the surface of a balloon. As the balloon expands, the distance between any two dots increases, but the dots themselves don't really move.

Locally, galaxies still feel each other's gravity. As a result of this attractive force, they can move toward each other when the attraction due to local gravity overcomes the space-time stretching. This is why the Milky Way and Andromeda galaxies are on a collision course. If the currently observed acceleration of the cosmic expansion continues, then systems that are not already gravitationally bound will never get a chance to do so. — **MARIO LIVIO,** SPACE TELESCOPE SCIENCE INSTITUTE, BALTIMORE

COMING NEXT MONTH...
How can the corona be the hottest part of the Sun? Post your comments about this question online at www.Astronomy.com/forums.

Send your questions via e-mail to: askastro@astronomy.com; or write to: Ask Astro, P. O. Box 1612, Waukesha, WI 53187. Be sure to tell us your full name and where you live. Unfortunately, we cannot answer all questions submitted.

Begin your observing year with 16 bright, but little-known, open clusters. /// BY STEVE COE

Observe winter's forgotten star clusters

Some skywatchers have seen few open clusters because "They all look the same." However, I think open clusters show a variety of sizes, shapes, star counts, and detail. In the February 2007 issue, I wrote about the best open clusters in the winter Milky Way. That story covered 12 groups — some from French comet-hunter Charles Messier's (1730–1817) catalog and some from the NGC list. Let's look at 16 more open clusters that get little attention. We'll move along the Milky Way from north to south and enjoy great targets that lie off the beaten path.

Spend a few minutes at the eyepiece with each of these beauties, and see if you can pick out some of the features I've seen. Undoubtedly, you'll add details I didn't notice, and you'll discover some new favorites to add to your observing list.

Start high in Camelopardalis

I found **NGC 1502** easily through a 4-inch refractor observing from Arizona Sky Village in Portal, Arizona. A 21mm eyepiece (29x) showed it as bright and compressed, which means the stars didn't resolve well.

I counted 10 stars. Averted vision revealed another 10. A prominent double star lies at the center, and I split it easily even at 29x. Both objects are blue-white.

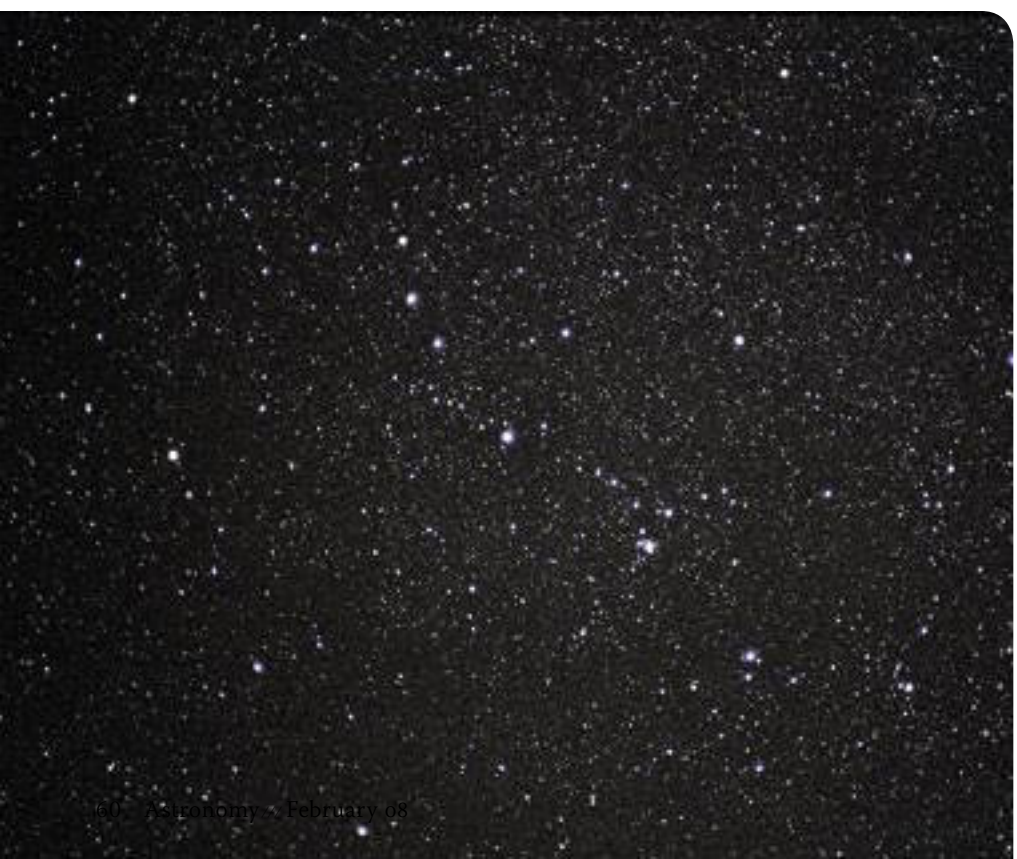
NGC 1502 looks bright, large, and robust at 100x through a 13-inch Newtonian reflector. I counted 27 stars, including several bright pairs and a blue-and-gold double on the northeast side.

NGC 1502 also is appealing because it lies at the southern end of Kemble's Cascade. This 2½°-long chain of stars is an easy catch through 8x42 binoculars, even from a somewhat light-polluted site. Binoculars reveal Kemble's Cascade as 12 stars with a "glow" at the end that is NGC 1502. A 4-inch wide-field scope captured the entire chain, showing 32 stars along the way.

Perseus is next

NGC 1245 is bright, irregularly round, rich, and compressed at 125x through my 11-inch scope. Several lovely star chains loop through the cluster. I counted 55 members at 200x, including several delicate pairs. Through my 4-inch scope, I resolved 9 stars, and averted vision showed about 20 more in this bright and obvious cluster.

NGC 1528 has been a favorite of mine for years. Through my 4-inch scope and the 21mm eyepiece, it appears bright and large from a dark observing site. Several curved star chains are easy to spot.

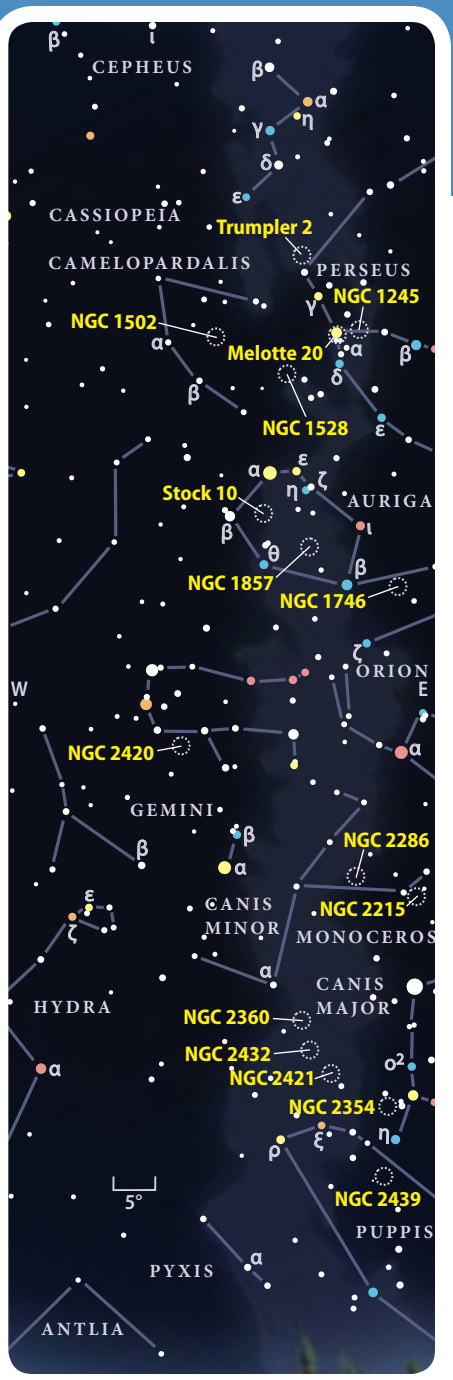


NGC 1502, at magnitude 6.9, is a bright but compressed cluster. It's famous among observers because it lies at the southeast end of Kemble's Cascade, a 2.5°-long string of some two dozen stars. STEVE COE

NGC 1528 in Perseus fascinates observers because it contains stars of many colors. At magnitude 6.4, this rich cluster is an easy target through binoculars. LEE C. COOMBS

TRUMPLER 2 lies 2° west of magnitude 3.8 Eta (η) Persei and just slightly more than 2° east-southeast of the Double Cluster (NGC 869 and NGC 884). LEE C. COOMBS

NGC 1245 delights observers using magnifications above 100x because of its looping chains of stars. NGC 1245 sits 3° south-southwest of Mirfak (Alpha [α] Persei). LEE C. COOMBS



USE THIS CHART to target all 16 clusters described in the story. You'll spot them all easily through a 4-inch scope at a dark site. *ASTRONOMY*: ROEN KELLY

Using my 13-inch scope, I counted 85 stars in this cluster at 135x. The group is bright, rich, and somewhat compressed. A fascinating interplay of bright stars and dark lanes winds through it. Stars of different colors — blue, yellow, orange, white and gold — populate this attractive group. I have no doubt this cluster would have been a Messier object if the astronomer only had swept this area with his telescope.

Astronomers refer to **Melotte 20** as the Alpha Persei Association. This group of bright stars includes Mirfak (Alpha [α] Persei), and all the stars have the same motion through the galaxy.

Using 10x50 binoculars, I counted 39 stars in the area around Alpha Persei. The field's central 3° show many lovely star chains and wide pairs. One chain runs southeast from Mirfak and forms "the Saxophone," a curved line of stars that resembles that musical instrument.

Through the 4-inch scope at 25x, Melotte 20 fills 80 percent of the view. I saw 28 bright stars with another 55 faint ones. The curved chain of the saxophone shape comprises 7th- and 8th-magnitude stars.

Trumpler 2 is bright, large, rich, and somewhat compressed at 100x through my 13-inch scope. I counted 32 stars, including

NGC 1746 makes a pretty target because its stars vary greatly in magnitude and because the brighter stars lie near the cluster's edge. To view the entire cluster, be sure your telescope/eyepiece combination yields a 1° field of view. MARTIN C. GERMANO

a nice blue-and-gold double to the southwest. One obvious chain of 8th- and 9th-magnitude stars lies in the cluster. Find Trumpler 2 about 3° from the more famous Double Cluster (NGC 869 and NGC 884).

Auriga awaits

NGC 1857 is easy to see at 125x through my 11-inch telescope. It's bright, large, and contains 25 stars, including one bright orange star in the cluster's center. Several curved chains of faint stars radiate from the orange star. Unlike Trumpler 2, this cluster appears well-detached from the Milky Way background of stars.

Stock 10 is a cluster that did not make it into the New General Catalog (NGC). Using the 4-inch scope and a 30mm eyepiece (20x), I counted 16 stars against a fuzzy background. The brightest three stars sit in the middle, and a sprinkling of fainter members surrounds them. Through my 11-inch scope and a 35mm eyepiece, this star cluster looks bright, large, and somewhat compressed. Its stars shine at magnitude 7 and fainter. I counted 41 stars. Of these, the dimmest 25 are fainter than 11th magnitude. This cluster provides a fine mix of bright and faint stars.

Stop in Taurus and Gemini

NGC 1746 in Taurus is a big cluster — I counted 14 stars through an 11x80 finder scope. My 13-inch scope at 60x shows it as bright and uncompressed. I counted 60 stars at this power, including a prominent orange star on the south side. This group takes up the entire 1° field of view. It does present a bizarre layout for an open cluster; the brighter stars lie on its rim with the fainter members "herded" near the center.

NGC 2420 in Gemini appears bright, large, and compressed at 100x through my 13-inch telescope. I counted 30 stars within

OBSERVE GREAT, LESSER-KNOWN CLUSTERS

Target	Constellation	Right ascension (2000.0)	Declination (2000.0)	Magnitude
NGC 1502	Camelopardalis	4h09m	62°21'	6.9
NGC 1245	Perseus	3h15m	47°16'	8.4
NGC 1528	Perseus	4h16m	51°14'	6.4
Melotte 20	Perseus	3h22m	49°	1.2
Trumpler 2	Perseus	2h38m	56°02'	5.9
NGC 1857	Auriga	5h21m	39°21'	7.0
Stock 10	Auriga	5h40m	37°34'	5.0
NGC 1746	Taurus	5h04m	23°46'	6.1
NGC 2420	Gemini	7h39m	21°34'	8.3
NGC 2215	Monoceros	6h21m	–7°17'	8.4
NGC 2286	Monoceros	6h48m	–3°09'	7.5
NGC 2354	Canis Major	7h15m	–25°42'	6.5
NGC 2360	Canis Major	7h18m	–15°39'	7.2
NGC 2421	Puppis	7h37m	–20°37'	8.3
NGC 2432	Puppis	7h41m	–19°06'	10.2
NGC 2439	Puppis	7h41m	–31°42'	6.9

Steve Coe *is a member of Phoenix's Saguaro Astronomy Club. His most recent book is* Observing Nebulae *(Springer, 2006).*

NGC 2420 in Gemini orbits the Milky Way's center 35-percent farther out than the Sun. About 2 dozen stars shine against an unresolved stellar backdrop. ADAM STUART

the cluster and an unresolved background of stars persisted even when I increased the magnification to 165x. A curved chain of stars around the central clustering has the shape of the constellation Corona Borealis.

A nice pair in Monoceros

I saw **NGC 2215** through 10x50 binoculars, so it is obviously a bright cluster. Using my 11-inch scope at 125x, I counted 36 stars that shone fainter than magnitude 9. I rate the cluster as bright, large, rich, and uncompressed. This cluster appeared well-detached from the Milky Way through my 11-inch telescope when I was far from city lights in the dark Arizona desert.

When I observed this cluster from my backyard observatory within Phoenix's light-dome, I had a different view. At 100x through an 8-inch scope, I saw only eight stars and a fuzzy background.

Through my 13-inch scope, the next target, **NGC 2286**, appeared bright, large, rich, and somewhat compressed at 165x. I counted 52 members with lots of faint stars forming a grainy background. Several dark lanes wind through the cluster.

SHARP-EYED OBSERVERS may spot magnitude 6.5 NGC 2354 in Canis Major from a dark site without optical aid. Through a telescope, note the oval ring of stars around the cluster's center. JIM BARCLAY

Canis Major beckons

You can see **NGC 2354** through 10x50 binoculars, but the best views are telescopic. This cluster is bright, large and somewhat compressed at 100x through my 13-inch scope. I counted 40 stars in a rich Milky Way field. Several dark lanes appear in this group along with some nice star chains.

NGC 2354 stands out nicely against the Milky Way's star fields. Most unusual are the 14 stars that form an oval ring around the cluster's middle. The core, however, contains no stars. This unusual shape makes NGC 2354 a memorable sight.

NGC 2360 is bright enough to be visible through your finder scope, but it sparkles through large instruments. At 100x through my 13-inch scope, it looks bright, large, compressed, rich, round, and well-detached from the Milky Way. I counted 20 bright stars with another 50 fainter ones that fill in the round shape. Several nice star chains also caught my eye.

NGC 2360 in Canis Major measures 14' across and shines at magnitude 7.2. English astronomer Caroline Herschel (1750–1848) discovered NGC 2360 in 1783. GEORGE R. VISCOME

Finish low in Puppis

Northern Hemisphere observers sometimes skip Puppis because it lies near the horizon. This constellation contains many open clusters worth an extended look, however.

Start with **NGC 2421**. It looks bright, large, rich, and somewhat compressed at 135x in my 13-inch scope. I counted 28 stars of magnitude 11 and brighter. The cluster is detached from the Milky Way. A bright double star sits at the center, and several star chains surround this showpiece.

Next, move to **NGC 2432**, which, like NGC 2421, appears bright, large, and compressed. Through the 13-inch telescope, I counted 26 stars. This unusual cluster appears 3 times as long as wide, on a north-south line. Few open star clusters veer far from a round configuration. Averted vision can add many faint stars to the count.

Finally, observe the bright, rich cluster **NGC 2439**. I counted 42 stars at 100x through my 13-inch scope. This cluster's center is dark, which gives the cluster a horseshoe shape. One bright yellow star, which is not part of the horseshoe shape, sits on the eastern edge. This shape is unique among star clusters I've observed.

Messier cataloged many great objects, but he left off lots of gems for you to discover — and these standout open clusters prove it.

WEB EXTRA Find 12 more winter open clusters to observe at www.Astronomy.com/toc.

Observing and imaging are top priorities at Arizona Sky Village, a remote community that may be amateur astronomers' paradise.

/// **TEXT AND PHOTOS BY MICHAEL E. BAKICH**

The darkest sky under the stars

Imagine stepping into your yard at night and seeing no clouds, streetlights, or light pollution. It's not a dream; such a place exists, and you can live there.

Arizona Sky Village (ASV) in Portal, Arizona, enjoys some of North America's darkest and clearest skies year-round. With few exceptions, clouds appear only during the Southwest's monsoon season, from mid-June to mid-August.

A timely idea

Developer Gene Turner, formerly of Florida, paired up with legendary deep-sky photographer Jack Newton to create an astronomer's haven far from traffic, noise, and city lights. Turner, who has acquired several thousand acres, planned ASV in three stages. Stage 1, laid out in 40 four-acre plots, has already sold out.

Each lot comprises four acres of deed-restricted property. ASV provides underground power and telephone service. ASV allows each owner to construct one single-family dwelling and an observatory on each four-acre lot. The combined space of the house and observatory must total at least 1,000 square feet.

Turner plans 11 time-share haciendas. Each will be fully furnished with three bedrooms and two bathrooms. Haciendas will come with all utilities, including high-speed Internet access and remote robotic wide-field telescope linkage.

Also included with each unit is a 14-inch computerized telescope located in a private, open-air observation courtyard. Unit owners will have access to the Community Observatory, which contains a 30-inch computerized Starmaster telescope.

Beautiful surroundings

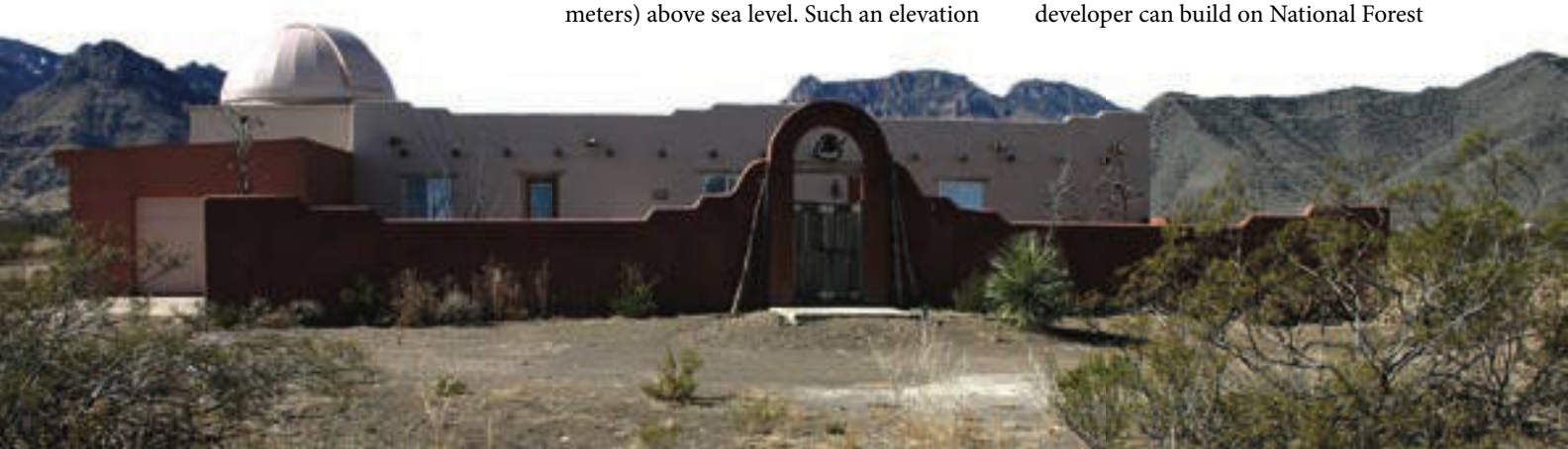
ASV sits in the foothills of the Chiricahua Mountains at the mouth of Cave Creek Canyon. The land lies 4,600 feet (1,400 meters) above sea level. Such an elevation ensures low humidity and also keeps the summers from becoming too hot.

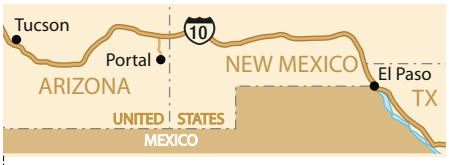
Because of its high elevation, ASV enjoys a warm year-round climate without the extreme heat of some other southwestern locations. The high through the summer months averages 90° F (32° C), and the average high during winter is 58° F (14° C). Total annual precipitation averages a moderate 17.4 inches (44 cm).

This location offers several advantages because it abuts the Coronado National Forest. First, residents can explore the canyon's magnificent rock walls and wooded terrain and enjoy some of the best birding in the United States. The other advantage directly affects amateur astronomers. No developer can build on National Forest

RICK BENO operates a 16-inch Meade Schmidt-Cassegrain telescope in his observatory, which he named Conferring with the Sky. The structure features an exterior deck, lots of storage, and desk space for star charts.

JACK NEWTON, world-renowned astrophotographer, lives here with his wife Alice. His attached observatory houses a 16-inch Meade Schmidt-Cassegrain telescope. Newton routinely monitors the Sun and searches for supernovae. He's found two new supernovae searching from ASV.





ARIZONA SKY VILLAGE is in Portal, Arizona, at 109°08' west longitude and 31°55' north latitude. This location sits 150 miles (242 km) from Tucson International Airport in Arizona and 160 miles (258 km) from El Paso International Airport in Texas. To drive from either city, take Interstate 10. Portal lies approximately 25 miles (40 km) south of I-10. *ASTRONOMY:* JAY SMITH

land, so this area, comprising some 1.78 million acres, will stay dark.

Other enjoyment

A dark sky, though, doesn't paint the whole picture. Besides the superb birding and exploring in the adjacent forest, you can enjoy mineral collecting. Many abandoned mines dot the area. The region abounds with copper and silver ores.

Historically, Native Americans lived in this region. As Turner and I walked property lines, he bent down and found a pottery fragment hundreds of years old. The area also belonged to the "Wild West." Some of the greatest gunslingers who frequented Tombstone and Bisbee, Arizona, hid out in the mountains near ASV.

Dark-sky observing

I spent two not-quite-sleepless nights at ASV. The first featured some hit-and-miss cumulus clouds, but the second was totally clear. As evening twilight progressed, the sky darkened, except toward the west. The intense glow I saw, however, wasn't from light pollution. Rather, the triangular-shaped zodiacal light (produced by sunlight reflecting off solar system dust), usually just a dim glow, began to brighten. When the last vestige of twilight faded, the zodiacal light actually reached the zenith — a first for this long-time observer.

The evening's highlights, however, came with each view through ASV's 30-inch Starmaster reflector. This f/4.3 Dobsonian-mounted Newtonian reflector boasted full computer control and superb optics. Viewing through such an instrument, I found it difficult to call normally faint deep-sky objects "challenges."

Michael E. Bakich *is a senior editor of* Astronomy.

A REMOTE-CONTROLLED 12-INCH TELESCOPE used for imaging sits in this dome near the 6,400-foot (1,950 meters) summit of Norrick Peak. Arizona Sky Village owns this peak, and developer Gene Turner envisions many more telescopes atop it.

CONFERRING WITH THE SKY Observatory is the handiwork of Rick and Vicki Beno, who attached it to their house. To prevent vibrations at the eyepiece or camera, the observatory's telescope is not attached to the house; Beno anchored it separately to the ground.

Astronomy Editor David J. Eicher, who accompanied me to ASV, succinctly summed up our observing session: "Bright objects made our jaws just drop."

The Orion Nebula (M42) appeared etched in the sky, with phosphorescent detail glowing in greenish-white light, hues of pink visible throughout the brightest portions. The Witch-Head Nebula (IC 2118) in Eridanus was plain to see.

The Horsehead Nebula (B33) was well-defined, the horse shape clear to see with direct vision. NGC 2359, an emission nebula nicknamed Thor's Helmet, was a stunner: It looked photographic, the bubble surrounding the central Wolf-Rayet star replete with fibrous details. The Rosette Nebula looked like a short-exposure photograph. Many more objects were just amazing, almost beyond description.

Final destination?

In this era of increasing light pollution, it's getting harder to find dark skies — especially those that will remain so. Because of its prime location, fabulous natural amenities, and careful management, Arizona Sky Village is a haven for amateur astronomers.

If you like to be kept in the dark, this development is for you. Who knows? Perhaps someday we'll be neighbors there.

CONTACT INFORMATION

Arizona Sky Village
P. O. Box 16411
Portal, AZ 85632
[t] 520.558.1128
[w] www.arizonaskyvillage.com

Beginning astronomers take note: You can identify celestial objects like a pro. /// **BY MIKE D. REYNOLDS**

Meade's mySKY teaches you the stars

Meade Instruments Corp. offers a simple solution for novice stargazers to find and identify celestial objects: mySKY. This handheld device will answer questions like, "What's that bright star?" "Where is the Andromeda Galaxy?" and thousands of other queries.

For most observers, it takes time to learn the night sky. Some use star atlases; others learn the star-hopping technique; a minority rely on their telescopes' setting circles, navigating by celestial coordinates. Some beginners find these challenges enjoyable. Others would rather simply observe, learning the celestial road map as they go along.

When Celestron introduced SkyScout, its handheld point-and-identify unit, in late 2006, amateur astronomers wondered how long it would take Meade Instruments to follow suit with a similar product. The company answered that question with mySKY, an interactive handheld night-sky guide. Like the SkyScout, mySKY's GPS technology pinpoints celestial objects with ease. mySKY provides integral video and audio descriptions of objects, as well as direct control of Meade computerized telescopes (this requires an optional cable).

Easy and fun to use

When I opened the mySKY package, I was struck by how the unit looks like a handheld police radar unit or something out of science fiction. I found mySKY easy to hold: well-balanced, comfortable in my hand, and not too heavy. It's also easy to operate, with the buttons logically laid out.

LCD brightness and volume controls are on the left side of the unit. Meade includes a set of ear-bud-type earphones. The unit requires four AA batteries. Company advertising states the batteries will last for 6 hours of operation.

The instrument includes a brief introduction video featuring Scott Roberts, Meade's vice-president of marketing, which steps the user through general use of the unit. Acquisition of the GPS signal took about 2 minutes.

Once you acquire a GPS lock, you can use mySKY in a couple of different modes to locate objects. I like the feature that connects you to your previous observing session after you turn mySKY on again. It saves connection time.

Point mySKY at any object by aligning the three red LED sights on top of the unit. Or, use the go-to feature to have mySKY direct you to the object via an on-screen arrow that changes size.

You can adjust the brightness of the three LEDs with the "Light Balance" option. A brief video introduces you to most well-known objects. It took the mySKY "Locate" function only a few seconds to identify each object.

I found mySKY surprisingly accurate, but it isn't infallible. Occasionally, it incorrectly identified objects. I asked a couple of my college students to try using mySKY. They noted it was easy to use, and they liked the design.

It should be fairly easy to update the mySKY secure digital (SD) card-based content software. You'll need an SD-card reader connected to your computer. Then you can download future updates, including object data, from Meade's web site.

mySKY development

I had an opportunity to talk at length with Meade's Paul Hobbs, who helped develop mySKY. Hobbs noted that Meade had thought about something like mySKY years ago and debated how it would fit within its product line. When Celestron introduced the SkyScout, it brought the project back to the front burner at Meade.

Some of Meade's goals were to make mySKY interactive and fun — thus, the graphics and audio with Sandi Wood as the

Mike D. Reynolds *is the associate dean of mathematics & natural sciences and professor of astronomy at Florida Community College.*

/// SPECIFICATIONS

Meade's mySKY

Sight: Illuminated LEDs
Screen: Full-color LCD with 480x234 resolution
Audio: Ear buds
Memory: 256-Megabyte SD card
Database: 30,000+ objects
GPS: 12-channel GPS receiver
Power: 4 AA batteries
Battery life: Up to 6 hours (normal use)
Drives: Meade computer-controlled telescopes
Price: $399

narrator. Meade even considered the shape part of the "fun" design.

Hobbs says mySKY includes batteries at the base for two reasons: balance; and to place them at the maximum distance from the sensors and electronics, making mySKY more stable. The inset screen assures protection, and even the paint is non-metallic so as not to interfere with the GPS sensors.

Keeping the GPS sensor isolated is a major issue. If you use the unit too near a large ferromagnetic source (such as a steel storage building or a transmission tower), you will encounter interference.

Telescope control

Meade notes mySKY can be used directly with a Meade computerized telescope. I used mySKY with the RCX400 14-inch.

After carefully setting up and initializing the RCX400, I verified the scope's go-to features were working. I then connected mySKY to the RCX400 with an optional cable supplied by Meade.

I operated mySKY in a couple of different configurations with the RCX400. First, I used it as an object library, choosing the targets I wanted the RCX400 to "go to." I also used mySKY's point-and-shoot capability. I would point at an unknown object and then direct mySKY and the RCX400 to "go to" the object.

I tried about 30 different objects in varying mySKY modes — the mySKY/RCX400 combination never failed! It was spot on the object every time. I never had to readjust the telescope or center the object.

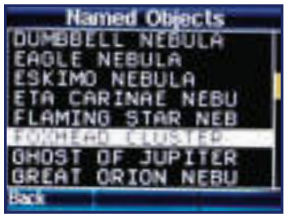
The only problem I encountered was deciding what to do with mySKY when the telescope was in the "go-to" mode. An after-market product like a holster attached via Velcro straps to the telescope's fork arm would be a nice addition.

Like almost every electronics product available today, Meade's mySKY will evolve. The first version is easy and fun to use. If you're conducting astronomy outreach events and public observing sessions, mySKY is a great teaching tool. And, observers — especially first-time stargazers — will not be disappointed.

◀ **MEADE'S mySKY will identify any celestial object you point at. Its intuitive design makes it easy to use.**

ASTRONOMY: WILLIAM ZUBACK

▲ **MANY well-known objects have images and detailed descriptions.**



▲ **mySKY has several search functions. Here, the screen displays object names.**

CONTACT INFORMATION

Meade Instruments Corp.
6001 Oak Canyon
Irvine, CA 92618
[t] 800.626.3233
[w] www.meade.com

BY GLENN CHAPLE

Surf the skies

Backyard astronomers universally

revile clouds. Where I live in the northeastern United States, overcast skies are often the rule. Thankfully, I've learned clouds don't have to bring my astronomical pursuits to a halt. A cloudy night can be a blessing in disguise. I can tinker with my astronomy equipment, perhaps fine-tune a reflecting telescope's alignment, or arrange the eyepieces in my toolbox. There's time to relax in the easy chair with the latest issue of *Astronomy* — no skimming through the pages tonight!

Later, I'll sit down at the computer. The web is my cloudy night haven, allowing access to literally hundreds of astronomy-related web sites — more than enough to keep me engaged for many a murky evening. Here are some of my favorites:

www.Astronomy.com. You could spend an entire cloudy evening exploring all the options our web site offers. Besides information on the current issue of *Astronomy,* you'll find how-to articles, astronomy news, reader forums, and much more. Be sure to check out the recently redesigned web site with its interactive StarDome, informative video clips, and new sky almanac.

www.cloudynights.com. This appropriately named site contains equipment reviews, forums, and classified ads. Two of my favorite cloudynights.com offerings are the periodic constellation close-ups written by frequent *Astronomy* contributors Steve Coe and Tom Trusock.

www.spaceweather.com. I go to this site for an update on solar and auroral activity. Spaceweather.com also details atmospheric phenomena and lists currently observable near-Earth asteroids.

www.cleardarksky.com. It's cloudy out now, but will skies clear later? What about tomorrow's observing conditions? Many amateur astronomers regard cleardarksky.com as their go-to site for detailed local weather conditions. In graph-like form, it includes a 36-hour forecast of cloud cover, seeing, and transparency for numerous locations across North America.

ASTRONOMY.COM'S redesign includes new features and user-friendly navigation.

www.astronomyclubs.com. Whether you want to locate a nearby astronomy club or simply learn about clubs elsewhere, astronomyclubs.com is your travel ticket. Its extensive listings take you to more than 1,000 astronomy clubs worldwide.

www.heavens-above.com. This handy site tells you what satellites will be visible from your part of the world tonight. Although that won't be of much help on a cloudy evening, you can obtain a 7-day prediction of major satellite flyovers and plan later observing sessions.

antwrp.gsfc.nasa.gov/apod/astropix.html. The "Astronomy Picture of the Day" could well be referred to as the "Astronomy Lesson of the Day." This daily astronomy-related image, accompanied by informative text, is popular with backyard and armchair astronomers alike.

www.nineplanets.org. Visit this site to glean useful facts about the solar system. It includes data on the planets and their satellites, as well as information about comets, minor planets, and meteoroids. You'll even find material about exoplanets.

www.inconstantmoon.com. Here's a great resource for all you "lunatics" out there. Among other Moon-related items, you'll find a daily Moon tour, a lunar atlas, and listings of past, current, and future Moon phases.

www.aavso.org. This is the official web site of the American Association of Variable Star Observers (AAVSO). Dedicated to amateur studies of variable stars, aavso.org offers everything from how-to articles, charts, and archival data to nova and supernova alerts. You can even download the AAVSO's Manual for Visual Observing of Variable Stars. Variable-star observations by amateurs are scientifically valuable.

www.messiermarathon.com and **seds.org/messier.** Deep-sky aficionados will delight in this pair of definitive Messier catalog sites. Both include historical footnotes, individual descriptions of all Messier objects, observing lists, and finder charts.

As for the multitude of astronomy-related web sites I didn't mention, just search for "astronomy web sites" on your favorite browser. Better yet, type in specific astronomical topics of interest. But be forewarned: The Internet is highly addictive. You may find yourself looking forward to cloudy nights.

Questions, comments, or suggestions? E-mail me at gchaple@hotmail.com. Next month: Seeing double (stars). Clear skies!

WEB EXTRA Check out *Astronomy* editors' favorite web sites at www.Astronomy.com/toc.

HomeDome/ProDome

PD10 – first of two – England

- True Rotating Dome
- Easy Assembly
- 6, 10, 15ft. Diameter
- All Fiberglass
- Motors & Automation
- Wide Slot Openings
- Complete Systems Priced from $2990

ROBOFOCUS™
Automated Focus Driver
with temperature compensation
$425

Technical Innovations, Inc.
7851 Cessna Ave.
Gaithersburg, MD 20879
Ph: 301-977-9000 • Fax: 301-977-1106

FREE BROCHURE
www.homedome.com • www.robofocus.com

Woodland Hills Telescopes

Order: Mon-Sat • 9-6 PT
Toll Free: 888.427.8766
P: 818.347.2270
F: 818.992.4486
WHtelescopes.com

5348 Topanga Canyon Blvd.
Woodland Hills, CA 91364

We have stellar solutions for all your Astro needs!
For triple rewards + other amazing deals, visit us at
www.WHtelescopes.com during Jan 18,19,20!

CELESTRON
Up to $200 in rebates with a SE telescope purchase

Nexstar GPS | CGE | CPC | Nexstar 8 SE

MEADE Up to $200.00 in rebates with an ETX telescope purchase

ETX | LX200R GPS | LX90 GPS

Vixen Optics

SkyPod w/VMC110 **$995**

GPD2 w/Starbook VMC200L **$2,595**
Regularly priced $3,495

SphinxD Mount **$2,495**

TeleVue Visionary

Eyepieces with FREE SHIPPING!
13% off the marked price on Tele Vue eyepieces

Plossl			
8, 11, 15mm	$85	20, 25mm	$99
32, 40mm	$119	55mm	$235
Radian			
3, 4, 5, 6, 8, 10, 12, 14, 18.0mm			$250
Zoom Nagler			
2-4mm	$395	3-6mm	$385
Click 8-24mm click stop			$215
Nagler Type 6			
13, 11, 9, 7.5, 3.5, 2.5mm			$290
Zoom Dioptrix 8-24mm			$240

We have ETHOS in stock

TAKAHASHI

The Triplet Ed Appochromatic will delight you with color free images

Takahashi TSA 102S

CORONADO

We now have the new Personal Solar Telescope, P.S.T.-CaK, in our store. It allows you to see and photograph solar flares and prominences safely. **$595**

P.S.T. CaK

The MAXSCOPE 40 Telescope with BF10 – New Low Price **$1699**

Canon KNOW HOW™ Cameras, Binoculars
Denkmeier
JMI
KENDRICK ASTRO INSTRUMENTS
Leica
LOSMANDY
MoonLite Telescope Accessories
ORION
PENTAX Scope, Eyepieces
SBIG
SKY COMMANDER
SB Software Bisque
Thousand Oaks Optical
WILLIAM OPTICS
AND MANY MORE!

WIN A FREE TELESCOPE! ENTER AT www.whtelescopes.com

Astro Haven invented the clamshell dome...

Astro Haven Enterprises expands the envelope.

Look for even more invention infused with the latest technology and tools to look at your solution a whole new way. We will continue to expand the best capability with the lowest cost of ownership for one purpose: to let everyone connect with their universe.

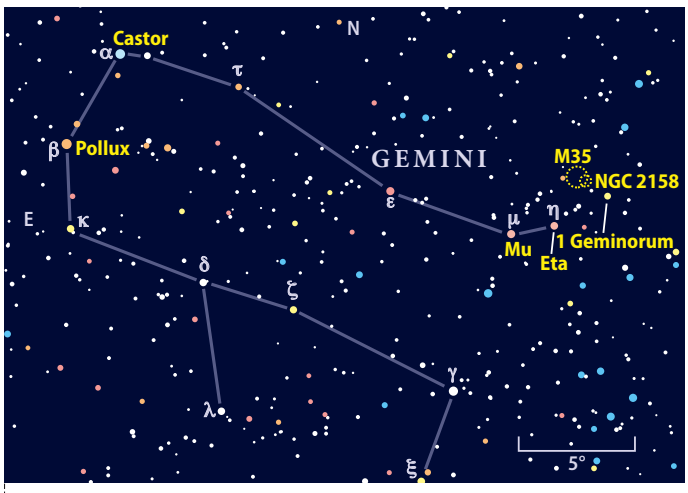
Non-rotating clamshell design is the cost effective solution to various instrument applications with sizes ranging from the **7 foot** and **12 foot** models to the big **16 foot** and **20 foot** domes.

www.astrohaven.com
949-215-3777
domesales@astrohaven.com

BY PHIL HARRINGTON

Meet the colorful Gemini twins

The Gemini twins, Castor and Pollux, were colorful characters in Greek mythology. Castor was a legendary horseman, while Pollux was a champion fighter. They are most famous as members of the Argonauts, led by the larger-than-life Jason. This band of heroes experienced many adventures while searching for the legendary Golden Fleece. Along the way, the inseparable Castor and Pollux clashed with Amycus, son of the sea god Poseidon and the nymph Melia. Later, the twins saved the Argonauts from certain doom during an especially ferocious storm.



GEMINI HARBORS a variety of colorful stars and several open clusters for binocular exploration. *ASTRONOMY:* ROEN KELLY

True colors

In modern times, Castor and Pollux remain colorful characters — literally. By scrutinizing both stars through your binoculars, you'll see that Pollux, to the east, appears orangish, whereas Castor is bluish-white. That's because Pollux is an orange giant star, whereas Castor is a multiple-star system dominated by two white main sequence suns.

Unfortunately, you'll need at minimum a 3-inch telescope at 150x magnification to discern this star system's two brightest members. Binoculars may, however, reveal another star in Castor's family — a dim point just to the southeast. All three of these stars in Castor are, themselves, binary star systems. This means Castor is actually a sextuple star.

Two more colorful stars lie nearby. Follow the pattern of Castor's stick-figure body down toward his feet. Pause at the stars labeled Mu (μ) and Eta (η). By defocusing their images, you should detect both stars' reddish-orange hue.

These red giants vary slightly in brightness, just as most red giants do. Mu flickers between magnitudes 2.8 and 3.0, which is far too subtle to monitor visually. Eta's broader range, from approximately magnitude 3.3 to 3.9, is easier to perceive across its 234-day period.

Just west of Eta and Mu is a third star labeled 1 Geminorum. If Eta and Mu mark Castor's foot, then this must be the big toe. Like the Sun, 1 Gem is classified as a yellow main sequence star. Can you detect its pale golden color in contrast to Eta and Mu?

Clustermania

Together, Mu, Eta, and 1 Gem create a three-star arc that curves beneath the open cluster M35 — the brightest deep-sky target within Gemini and one of my winter favorites. I think of M35 as the "Soccer Ball Cluster," because it looks like Castor is about to kick it. More than 200 stars lie within. Two dozen of them shine brighter than 10th magnitude, making then visible in binoculars. M35 lies some 2,800 light-years away.

Once you've spotted M35, try your luck with NGC 2158, another open cluster just ¼° southwest of the Soccer Ball. (Charles Messier may have missed it in 1764, when he cataloged M35.) You can glimpse NGC 2158 through steadily supported 10x50s on a dark night. Give it a try, but remember that you are looking for a small, very faint grayish blur.

NGC 2158 is one of the most unusual open clusters in the winter sky. Its great distance, estimated at 16,000 light-years, puts it very near the edge of our galaxy. It is also one of the oldest open clusters known. Judging by its unusually high number of mature yellow and red stars, NGC 2158 may be more than a billion years old. M35, comprised primarily of young blue-white stars, is only about 150 million years old.

Next month, it's time for the annual Messier Bino-thon. Till then, remember that two eyes are better than one.

ONLINE EXTRA Discover additional star clusters in Gemini and the elusive Eskimo Nebula at www.Astronomy.com/toc.

Buy your Celestron accessories at OPT...or else!

PREMIER SELECT CELESTRON DEALER

OPT has the experts to help you choose from the complete line-up of Celestron accessories. Mounts and PowerTanks to filters and eyepieces (including the exciting new Axiom series), we have it all. FREE shipping on all Celestron accessories (12-26-07 until 01-10-08)

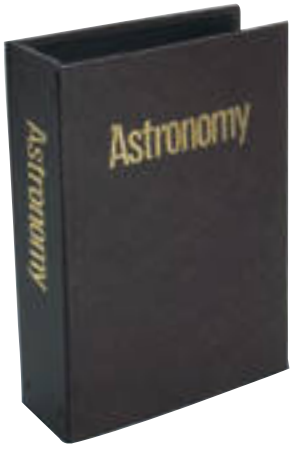
Craig Weatherwax, "The Don" & Founder of OPT.

OPT 800.483.6287 optcorp.com

Don't miss an issue of the **world's best-selling** *Astronomy* magazine!

- Spectacular photography
- Expert observing tips
- Readable, user-friendly articles
- Timely science reporting
- Monthly pull-out star maps
- *And much more!*

PROTECT YOUR INVESTMENT!



Preserve your library of *Astronomy* magazines with durable hardcover binders.

ITEM NO. 14007
1 for $13.95 • 3 for $38.95 • 5 for $59.95

Order yours today!

TO ORDER BY MAIL: Send your order to Kalmbach Publishing Co., Dept. A2002, 21027 Crossroads Circle, P.O. Box 986, Waukesha, WI 53187-0986. Use chart to the right for shipping & handling charges.

MERCHANDISE TOTAL	ADD
$15.00 or less	$4.95
$15.01–$30.00	$5.50
$30.01–$50.00	$6.50
$50.01–$75.00	$7.50
Over $75.00	$8.50

Canada add an additional $2.00, other foreign add an additional $5.00. For Wisconsin delivery, add 5% sales tax to total; for Pennsylvania delivery, add 6% sales tax to total. For delivery in Canada add 6% GST to total. Payable in U.S. funds. Checks must be drawn on a U.S. bank except for those from Canada; GST included. Make checks payable to Kalmbach Publishing Co. Prices and availability subject to change.

call 1-800-533-6644
Mon–Fri, 8:30am–5:00pm Central Time.
Outside the U.S. and Canada, call 262-796-8776.
Please have your credit card ready.

fax 262-796-1615

www AstroMagBooks.com
Secure online ordering available.

Astronomy

A30785AD A2002

Nothing improves your scope more than a $69.95 1.25" Astro-Tech *dielectric* diagonal.

No matter how good your telescope, it's no better than your star diagonal. The cheap prism diagonal that comes with most new scopes invariably limits your visual performance. The **Astro-Tech** 1.25" *dielectric mirror* diagonal – a *Sky & Telescope Hot Product for 2007* – won't limit the view through your scope. It shows you everything your scope sees.

Like *all* Astro-Tech diagonals, the 1.25" has durable 46-layer 99% reflectivity dielectric coatings on its BK7 optical glass mirror substrate. Its brass compression ring eyepiece holder won't scratch your eyepiece barrels.

The 2" diagonals have separate 1.25" and 2" compression ring eyepiece holders. You can choose a 2" barrel for refractors or a threaded ring that fits Schmidt-Cassegrain rear cells.

The 2" *quartz* diagonals have 1/10th wave peak-to-valley accuracy – *even after being coated!* Each quartz diagonal includes its own interferogram to guarantee its performance.

Here are the five **Astro-Tech** diagonals:

1.25" – *a Hot Product for 2007* **$69.95**
2" with 1.25" adapter .... *139.95* ... ***sale*** **119.95**
2" SCT with 1.25" adapter **149.95**
2" quartz with 1.25" adapter **189.95**
2" quartz SCT with 1.25" adapter **199.95**

Everyone should own this Astro-Tech!

Astronomy magazine said the $349 **Astro-Tech AT66ED** was "a product everyone should own." This remarkable 66mm f/6 ED doublet refractor is sharp, contrasty, and virtually free of chromatic aberration. Great visually, it is also a truly superb astrograph and telephoto lens.

The AT66 has a rotating dual-speed Crayford focuser; a 1.25" compression ring eyepiece holder; a hard case; and a dovetail that fits photo tripods or Celestron, Meade, and Vixen mounts.

Competitors? At $1195 there are none!

No competitive refractor gives you the same array of features that you get with the **Astro-Tech AT102ED** for $1195.

You get a genuine *Feather Touch* dual-speed micro-focuser that's custom-made for the AT102ED*; illuminated multiple reticle finder*; locking hard case*; dual split hinged tube rings with a detachable 8" dovetail*; 102mm f/6.95 ED doublet optics; retractable dew shield; rotating Crayford focuser; 1.25" and 2" compression ring eyepiece holders; a *two-year* warranty*; and more.

Competitive scopes just can't compete.

*Unavailable or optional with some or all competitive scopes.

ASTRO-TECH
from **Astronomy Technologies**

Astro-Tech is available at these U. S. dealer websites:
astronomics.com • highpointscientific.com
auroraastro.com
In Europe, Astro-Tech is available at these websites:
aleph-lab.com • locascope.com
robtics.nl • scsastro.co.uk
Dealer inquiries: info@astronomytechnologies.com

SKYPOD MOUNT
Vixen Optics, San Clemente, California

Vixen's portable, alt-azimuth, computer-controlled go-to mount features a 22,000-plus object database. The Skypod flexible mounting system lets you remove the integrated controller.

Price: $899, with tripod
[t] 949.429.6363
[w] www.vixenoptics.com

FERRARI ZenithStar RACING EDITION 2.6-INCH (66MM) APO REFRACTOR
William Optics, Cypress, California

The Ferrari ZenithStar Racing Edition 2.6-inch (66 millimeters) APO f/5.9 telescope features a Crayford-style rotatable focuser.

Price: $699
[t] 866.918.6888
[w] www.williamoptics.com

FAR-Sight BINOCULAR MOUNTING SYSTEM
Farpoint Astronomical Research
Gold River, California

The FAR-Sight binocular mounting system works with parallelogram mounts or tripod heads with standard ¼" (6mm) mounting holes.

Price: $69.95
[t] 877.623.4021
[w] www.farpointastro.com

PERSONAL OBSERVATORY DOME
SkyShed Observatories, Staffa, Ontario

Assemble SkyShed's XL5 Personal Observatory Dome (POD) from 10 polyethylene panels. The XL5 POD features 5 storage bays and a dome that rotates 360°.

Price: $2,295
[t] 519.345.0036
[w] www.skyshed.com

SmartStar-E GO-TO MOUNT
iOptron Corporation
Woburn, Massachusetts

The SmartStar-E go-to alt-azimuth mount includes computerized control and tracking, a 5,000-object database, and a tripod.

Price: $199
[t] 866.399.4587 [w] www.ioptron.com

DOBSONIAN-MOUNTED 10-INCH f/6 TRUSS TELESCOPE
Astro Sky Telescopes
Lake Charles, Louisiana

This Dobsonian-mounted 10-inch (25.4cm) f/6 truss telescope features a Wodens mirror and Baltic birch plywood.

Price: $1,859, plus $125 shipping
[t] 337.474.4716
[w] astrosky.homestead.com/Astrosky.html

ULTIMA LX SERIES EYEPIECES
Celestron, Torrance, California

Ultima LX series parfocal eyepieces boast a 70° apparent field of view and twist-up eyecups.

Price: $201.95 each: 5mm, 8mm, 13mm, 17mm; $259.95 each: 22mm, 32mm
[t] 310.328.9560
[w] www.celestron.com

VistaPix 8x22 DIGITAL CAMERA BINOCULARS
Celestron, Torrance, California

VistaPix 8x22 digital camera binoculars feature a removable telephoto lens.

Price: $251.95
[t] 310.328.9560
[w] www.celestron.com

18-INCH f/4.2 ULTRA COMPACT TELESCOPE
Obsession Telescopes
Lake Mills, Wisconsin

Obsession's 18-inch (45.7cm) f/4.2 Ultra Compact telescope includes a Feathertouch focuser, Telrad finder, external light baffles, and counterweights.

Price: $6,340
[t] 920.648.2328
[w] www.obsessiontelescopes.com

TAKAHASHI EPSILON 180-ED 7.1-INCH (180MM) APO ASTROGRAPH OTA
Texas Nautical Repair, Houston

Takahashi's Epsilon 180-ED 7.1-inch (18cm) f/2.8 optical astrograph optical-tube assembly has a 19.7" (500mm) focal length.

Price: $4,995 (optical-tube assembly only)
[t] 713.529.3108
[w] www.takahashiamerica.com

TAKAHASHI SKY-90 3½-INCH (90MM) APO REFRACTOR OTA
Texas Nautical Repair, Houston

Takahashi's Sky-90 3½-inch (90mm) f/5.6 APO refractor is 13.8" (35cm) long.

Price: $1,995 (optical-tube assembly only)
[t] 713.529.3108
[w] www.takahashiamerica.com

TAKAHASHI TSA-102S 4-INCH (102MM) APO REFRACTOR OTA
Texas Nautical Repair, Houston

The TSA-102S 4-inch (102mm) triplet apochromat (APO) f/8 refractor optical-tube assembly by Takahashi is 23" (58.4cm) long and weights 11 pounds (5 kilograms).

Price: $2,695 (optical-tube assembly only)
[t] 713.529.3108
[w] www.takahashiamerica.com

Web Site Directory

Check out these businesses...
They're only a click away!

ASTROZAP
astrozap@yahoo.com
www.astrozap.com
Your #1 source of dew prevention shields on the planet. Hundreds in stock! Dew it in style!

EFSTONSCIENCE
sales@telescopes.ca
www.telescopes.ca
Science & Astronomy SuperStore since 1970. Canada's best prices selection and staff.

FOCUS CAMERA & VIDEO
www.FocusCamera.biz
Thousands of telescopes, eyepieces, accessories, binoculars, digital photography, & consumer electronics.
1-877-883-5937

OWL SERVICES
owl1@owlservices.com
www.owlastronomy.com
Special prices on Knight Owl Eyepieces Telescopes • Binoculars!
FREE # 1-888-OWL-WARE
10-6 EST M-F

SHUTAN CAMERA
Family Owned for 88 Years!
www.shutan.com
Located in Vernon Hills, IL. Large selection of astronomy & camera accessories. We carry Meade, Celestron, Televue, Nikon, Canon, and other brands. TOLL-FREE 866-621-6363

STARIZONA
Let's Talk Stars
www.letstalkstars.com
With your Hosts David and Wendee Levy
Astronomy talk radio

For advertising information call
1-888-558-1544
Ken Kozerski, ext. 636
Craig Greuel, ext. 495

INDEX of ADVERTISERS

20-20 Telescopes 75
Adirondack Video Astronomy 76, 77
Adorama 13, 51
Anacortes Telescopes & Wild Bird 76
Aridian Publishing 5
Ariel Optics 74
Ash Manufacturing 75
Astro Haven 69
Astro-Physics 76
Astromart.com 74
Astronomics 9
Astronomy.com 73
Astronomy magazine Binders 71
Astronomy magazine 74
Astronomy Technologies 71
Astrozap 73
Atomic Time 48
Beam of Light Technologies 77
Beta Electronics 76
Bethany Sciences 76
Big Bang Astronomy Shop 75
Binoculars.com 76
Celestron 82
Davis Instruments 21
Denkmeier Optical 75
Durango Skies 74
Efstonscience, Inc 73, 76
Equatorial Platforms 74
Farpoint Astronomical Research 75
Focus Camera 73, 76
Glatter Howard 75
Innovations in Travel 77
Jim's Mobile, Inc 21
Khan Scope Centre 76
Kitt Peak National Observatory 48
Let's Talk Stars 73
Luckyduck.com 75
Lumicon 48
M5 Records 75
Meade Instruments Corporation 2
Moonlite Telescope Accessories 77
New Mexico Astronomical 75
Observatory, Inc, The 75
Oceanside Photo & Telescope 51, 71
Orion Telescopes & Binoculars 4, 81
Owl Services 73
Pegasus Optics 77
Rainbow Symphony 75
Ritz Camera Superstores 74
Round Table Equatorial Platforms 74
Scope City 50
ScopeStuff 76
SCS Astro 76
Seymour Solar 74
Shutan Camera & Video 73
Sky Instruments 76
Smartastronomy.com 77
Software Bisque, Inc 18, 19
Solarscope 76
Southeastern Camera & Telescope 77
Stargazers Inn 76
StarGPS 77
Stellarvue 74
Technical Innovations 69
Tele Vue Optics, Inc 3
The Teaching Company 49
Thousand Oaks Optical 76
University Optics, Inc 74
Wicked Lasers 76
William Optics Co 50
Woodland Hills Camera & Telescopes 69
www.bigbinoculars.com 77

NEXT MONTH
in the March issue

ESO

Astronomy
The world's best-selling astronomy magazine

SPECIAL ISSUE!
ALL ABOUT GALAXIES

Quest for the first galaxies
New research gives astronomers a broad-brush view of how galaxies evolve. Now, they're filling in the details.

What happens when galaxies collide?
Simulations show a cycle of mergers, starbursts, and black holes built the universe's grandest constructions: giant elliptical galaxies.

Galaxies on fire
Starburst galaxies hold the key to understanding processes that shaped the youngest and most distant corners of the universe.

Bonus pullout poster: 1.5 million galaxies revealed!
The Two Micron All Sky Survey (2MASS) gives astronomers the first full 3-D view of the local universe.

Your scope and the seven dwarfs
Surprisingly, even small telescopes can reveal these seven dwarf galaxies.

Orion's BT70 binocular telescope
Binoculars take in lots of sky. Now, Orion has improved the classic design.

SUBSCRIBE TODAY!
1.800.533.6644
ORDER ONLINE AT
Astronomy.com

MARKETPLACE

DURANGO SKIES
TELESCOPE AND BINOCULAR
Providing a complete line of astronomy products for the casual observer to the serious astronomer. We specialize in Observatory Solutions for permanent installations.
www.durangoskies.com 970.259.5400 Durango, CO

TRACKING for DOBS
* High power observing and group viewing
*Astro-imaging with NO field rotation
call write or e-mail for free brochure
EQUATORIAL PLATFORMS 530-274-9113
15736 McQuiston Lane Grass Valley CA 95945
tomosy@nccn.net www.equatorialplatforms.com

AstroMart
Used Telescopes
www.astromart.com

ARIEL OPTICS
Antares Optics
THE SOURCE for ANTARES OPTICS SECONDARY MIRRORS
Ultra Precision, mirrors, prisms, beamsplitter, Wedge/Risley prisms, and light pipes
ArielOptics.com 585-265-4820 AntaresOptics.com

ROUND TABLE PLATFORMS
DOBSONIAN TRACKING PLATFORMS
Accurate tracking
Furniture quality - Simple to use
AFFORDABLY PRICED
847-202-1986
www.RoundTablePlatforms.com

Solar Filters for telescopes, binoculars, Spotting scopes, cameras, & view finders.
All sizes available from 2 inch to 16 inch
www.SeymourSolar.com
(541) 306-6178
Email: info@SeymourSolar.com

WOLFCAMERA
OUR EXPERTISE IS FREE!
EXPERTISE: Chuck Pisa, our staff astronomer, has 20 years experience recommending optical instruments to amateurs and professionals at our Sarasota location. You can e-mail questions to Chuck at cpisa@mindspring.com

SELECTION: We have a HUGE selection of products from telescopes, binoculars and CCD cameras to filters and eyepieces. If it's astronomy-related, we have it! We carry Meade, Celestron, TeleVue, and Apogee as well as a selection of used telescopes.
SARASOTA, FL
2069 Siesta Drive
(941) 955-3537 • (941) 366-8640 fax

UNIVERSITY OPTICS, INC.
P. O. Box 1205
Ann Arbor, Michigan 48106-1205
For over 45 years, your source for camera quality Japanese optics
Planetary Orthoscopics
Wide-Field Konigs
Mirror Cells & Spiders
Online Store
www.universityoptics.com
Call for FREE CATALOG
734-665-3575

Does your company's innovative new product need more exposure?

Send a product sample to Astronomy magazine for a new product review.
Mail your product to:
Astronomy Magazine
c/o New Products
21027 Crossroads Circle
Waukesha, WI 53186-4005
If you need more information contact editor@astronomy.com

SEIZE THE NIGHT!

STELLARVUE®
SEEING IS BELIEVING
WWW.STELLARVUE.COM
(530) 823-7796

Check out the new Astronomy.com

Our web site has a new look. And we've made it easier for you to find the things you need to tour the cosmos.

The NEW Astronomy.com includes:
- A home-page sky almanac
- An improved StarDome that allows you to interactively explore the night sky. PLUS - an enhanced StarDome for subscribers that displays comets, asteroids, stars, deep sky objects, and more.
- Atlas of the Stars, an interactive sky chart with the capability of zooming in on 24 overlapping maps.
- Web extras that take readers deeper into the stories found in *Astronomy*.
- And much more!

Visit Astronomy.com today to become the observer you always wanted to be!
Astronomy
CIR-ADW-07X1479RH

Collimation? Be Serious
Howie Glatter's Laser Collimators
& Accessories: Shockproof-Individually Tested
Hand Machined to < 0.0002" < 15 arc sec beam alignment
The original self-Barlow attachment
The Hugo Barlowed Laser Plug (pat. pend.)

Among the well collimated:
Palomar Observatory - Caltech
McDonald Observatory - University of Texas
Alan Adler, Paolo Candy, Nils Olof Carlin,
Attilla Danko, Ron Dantowitz,
Tippy D'Auria, Tom Dobbins,
"Stargazer Steve" Dodson, Brad Ehrhorn,
Dan Goldman, Phil Harrington,
Steve Kennedy, David Levy, Brian Lula,
Vic Maris, Vic Menard, Jim Misti
William McLaughlin, Mario Motta, Joe Nassal
James Malhotta, Tom Ozyporski,
Mike Reynolds, Don Parker, Yuri Petrunin,
Daniel Verschatse, Matthias Wirth

Howie Glatter 3850 Sedgwick Ave. Bronx, N.Y. 10463
Tel/Fax (718) 796 3203
www.skypointer.net www.collimator.com
e-mail: howieglatter@mindspring.com

Big Bang Astronomy Shop
We're Always Expanding!
Meade - Celestron - Orion - JMI - Televue Vixen -
Lumicon - Kendricks - Astrozap - Telrad - Thousand Oaks
RALEIGH, NC 866-352-BANG
www.BigBangAstro.com

SOUNDTRACK OF THE UNIVERSE
MUSIC FROM DEEP SPACE
Embark on a musical journey
through the cosmos as soundwaves
lift your spirit to higher dimensions
LOG ON TO PREVIEW
SAMPLES AND PRODUCTS!
www.myspace.com/m5rec
iTunes keyword: m5records

Why view through your scope with
ONE EYE when we let you use TWO?!
DENKMEIER
Systems starting at $499
www.denkmeier.com
Toll free: (866) 340-4578

20/20 TELESCOPES & BINOCULARS
TELEVUE CELESTRON MEADE ORION ASTROZAP JMI KENDRICK ZEISS
Chicago & NW Indiana's Friendly Dealer
708-474-2020
www.2020telescopes.com

The Most Complete
Telescope Store in Texas
Authorized dealer:
JMI, Orion, Celestron,
Meade, Tele Vue, Fujinon,
Vortex, Home-Dome,
Books, Charts, Software,
Service • Repairs
Private lessons
FREE instruction
at night with every
telescope purchase

The Observatory, Inc.
17370 Preston Road #370
(Two traffic lights north of Campbell Rd.)
Dallas, TX 75252 (972) 248-1450
www.TheObservatoryInc.com

NMA NEW MEXICO ASTRONOMICAL
Telescope Specialists
GRAND OPENING
NOVEMBER 2007 THRU JANUARY 2008
SPECIAL DISCOUNTS ON EVERYTHING!
MEADE - CELESTRON - TELE VUE - ORION
VIXEN - QUESTAR - PARKS - LOSMANDY
SEE OUR NEW SHOWROOM!
370A RIO COMMUNITIES BLVD
BELEN, NEW MEXICO 87002
(505) 720-5666 (505) 864-2953
www.nmastronomical.com

FOCUS ON
The Werner Schmidt Observatory
South Yarmouth, MA
The observatory located on the grounds of the Dennis-Yarmouth Regional High School is the only public observatory on Cape Cod. It has generated interest in astronomy. The project was funded by the Cape Cod Astronomical Foundation and built by the Cape Cod Regional Technical High School students. The building was designed to provide people with disabilities access via a CCD camera and monitor screen. It has been a welcome addition to the educational community.

ASH MANUFACTURING COMPANY
P.O. Box 312
Plainfield, IL USA 60544
815.436.9403 • FAX 815.436.1032
web site: www.ashdome.com
email: ashdome@ameritech.net
ASH-DOME is recognized internationally by major astronomical groups, amateurs, universities, colleges secondary & primary schools for their performance durability and dependability. Manual or electrically operated units in sizes from 8 to 30 feet in diameter; sensibly priced. Brochures and specifications available.

Ready—Aim—Learn!
The FAR-Sight Mounting System
- Now compatible with the Celestron® SkyScout™
- Stainless steel construction—Built to last
- Integrates with most porro-prism binoculars

Toll Free: (877) 623-4021 • www.FarpointAstro.com
FARPOINT
"The Farthest Point of Vision"™

The ONLY Green Laser Designed
Specifically for Astronomy!
Now with easy-aim telescope mount!
- Easily mounts to any telescope
- Can run for hours
- Designed to operate in cool weather
- 4 other models to choose from

Thousands sold—fast delivery & we ship worldwide.
Visit www.LuckyDuck.com/astronomymag or call toll-free 877-388-7362 for your special Astronomy Magazine discount.

(Shown here with one of several available telescope mounts—beam is simulated)

Jasper The next generation green laser.

ECLIPSE SHADES™
Safe Solar Viewers
Custom Imprinting Available

SAFE FOR DIRECT SOLAR VIEWING
CE Certified
The ultimate in protection from harmful solar radiation. Lenses are made of our exclusive scratch resistant optical density 5, "Black Polymer" material. Eclipse Shades filter out 100% of harmful ultra-violet, 100% of harmful infrared, and 99.999% of intense visible light. These premium filters create a sharper ORANGE colored image of the sun.
Rainbow Symphony, Inc.
6860 Canby Ave. #120, Reseda, CA 91335
(818) 708-8400 • Fax (818) 708-8470
eclipse@rainbowsymphony.com
www.rainbowsymphony.com/soleclipse.html

MARKETPLACE

ANTARES
High performance telescopes and accessories
www.antaresoptical.com

ScopeStuff
Telescope Accessories & Hardware
www.scopestuff.com
512-259-9778

EUROPE'S PREMIER WEBSITE
http://www.scsastro.co.uk
SCS ASTRO

METEORITES
Museum-Quality collectors' specimens. Meteorite jewelry, books, unique gift items. Authenticity guaranteed.
Color Catalog $3 USA, Canada and Mexico $6 Foreign Refundable with order.
The Universe Collection
P.O. Box 3726-A, New Haven, CT 06525-0726
203 393-3395 fax 203 393-2457
www.universecollection.com
VISA • MC • AMEX

Telescopes.com
UP TO 50% off retail!
World's Largest Selection of Telescopes!
www.telescopes.com 1-800-303-5873

Green Laser Pointer
points out the stars
www.betapointer.com
phone 800.546.2382

StarGazers Inn & Observatory
Nightly StarGazing in Private Observatory
Luxury B&B in Big Bear Lake, CA Offers Romance Under the Stars! Queen Featherbeds, Fireplaces, Candlelit Spa Tubs, Indoor Heated Pool, Sauna, Game Room, & More!
866-482-STAR (7827) www.stargazersinn.com
- Mention this ad for discount -

DISCOVER THE SUN...
847-579-0025
www.solarscope.com

So Many Ads. . .,
How Does One Choose?
ONE-STOP SHOPPING
For All Of Your Astronomy, Digital Photography and Consumer Electronics Needs
focus
CAMERA & VIDEO
MEADE • LEICA
CELESTRON
TELEVUE • CANON
BUSHNELL • ZEISS
HQ for SONY Alpha DSLR System
SONY α
like.no.other
SERVING CUSTOMERS HONESTLY SINCE 1966
TOLL-FREE
877.883.5937
www.focuscamera.biz

ASTRO-PHYSICS
Experience the ultimate in quality instruments for discriminating observers and astrophotographers.
Telescopes, Go-To German Equatorials, Visual and Photographic Accessories
Unparalleled Service and Support
Experience the legend that is
ASTRO-PHYSICS!
160mm f7.5 StarFire EDF
900GTO
11250 Forest Hills Road
Machesney Park, IL 61115, USA
Ph: 815-282-1513, Fax: 815-282-9847
www.astro-physics.com

Made in USA
See the Sun in Action!
Solar Filter sizes available for all Telescope types.
www.ThousandOaksOptical.com

HIGH-POWERED LASERS
GREEN, RED, and BLUE LASERS
wicked lasers
ORDER ONLINE AT WWW.WICKEDLASERS.COM

Visit us at
www.AstroClassifieds.com
FOR FREE
LIVE CHATS • CLASSIFIEDS • FORUMS
Sponsored by: Adirondack Video • BT Technologies • OPT

Anacortes Telescope
www.buytelescopes.com
800-850-2001

Khan Scope Centre
"The Astronomy shop with a Difference!"
©www.khanscope.com

For great deals, look North
We carry the complete line of SkyWatcher telescopes. Easy shipping to the U.S. & Canada
EfstonScience is Canada's #1 science and astronomy equipment dealer. Our knowledgeable staff of astronomy enthusiasts keeps our 8000 ft.² retail SuperStore jam-packed with the all the latest in hot scopes and accessories. And it is all online — shop for 1000's of products on our website at www.telescopes.ca. With great prices and easy shipping across North America, discover for yourself why EfstonScience has been Canada's brightest star for over 36 years, eh.
FEATURED BRANDS
• Meade • TeleVue
• Lumicon • Vixen
• Celestron • Pentax
• Thousand Oaks • Orion
NEW & USED EQUIPMENT
EfstonScience 36th ANNIVERSARY 1970 - 2006
Proudly Canadian
EfstonScience
The Science & Astronomy SuperStore
3350 Dufferin Street, Toronto, ON, Canada M6A 3A4
(416) 787-4581 (888) 777-5255 www.telescopes.ca

StarGPS

New "Plug & Play" GPS works with most GoTo telescopes, just $149

www.stargps.ca

PEGASUS OPTICS - Mirrors

★ Wavefront P-V <1/8 wave ★ 1.6 -2" thick ★IAD Coating

Dia.	FL	Price	Dia.	FL	Price
18"	75.6"	$2800	22"	100"	$5000
20"	90"	$3600	24"	110"	$6600

"You'll see the difference"

Web Site: PegasusOptics.Com E-mail: hallj@satx.rr.com
TEL: (210) 267-9937

Eclipse

China's Silk Road
Aug. 1
2008
or
Arctic Canada's
Land of the Midnight Sun

INNOVATIONS IN TRAVEL INC.
1-800-733-3361
E-mail: info@innovationsintravel.com
Web site: innovationsintravel.com

Galileo Would Be Jealous

...if he knew you had filters like these!

ASTRODON TRU-BALANCE FILTERS ...*Simplicity in Imaging*

- Other top brands such as Schuler Astro-Imaging, IDAS, Astronomik, Astro Solar Film, Baader, Lumicon, Optec, TeleVue, True Tech & more!
- All types- Visual, CCD, Video & Photo
- LRGB, Narrowband, Photometric, Light Pollution
- Filter wheels & many other filter holder solutions

www.astrovid.com
Call toll free: (877) 348-8433
ADIRONDACK Astronomy
The Astronomer's Source for Imaging

www.z-bolt.com

Green Laser Astronomy Gift Packs!!

Gift Pack includes:

Factory Tuned Green Laser Pointer

6" Remote Pressure Switch

Scope Mounting Bracket

NiMH Battery Charger/ 4 pcs AAA batteries

www.z-bolt.com/astrokits

Beam of Light Technologies, Inc.
Toll Free: 877-801-9299
Fax: 603-309-6020

bigbinoculars.com

Astronomical binoculars and accessories at down-to-earth prices. Visit our online store at www.bigbinoculars.com or call toll-free from 9:00 to 5:00 (EDT) 866-244-2460.

FUJINON MIYAUCHI OBERWERK

Southeasternskies.com

"Astronomy Products"

Storm Case Sale
10% off with eyepiece purchase

Choice of Colors

Cases to fit your eyepieces, telescope, binoculars and much more... Keeps electronic gear safe and dry.

Lifetime Warranty!

PENTAX
CELESTRON
MEADE

919-890-4484 Raleigh NC

SmartAstronomy.com

Vixen Optics

DenkMeier BinoViewers

ClearView Portable Observing Tent

TeleGizmos Scope Covers

Solar System Planetary Eyepieces

Meade-Coronado Telescopes

888.291.6577

MoonLite Telescope Accessories

www.focuser.com
570-275-7935

MARKETPLACE

Reader gallery

COMET 17P/HOLMES (14.5-inch RCOS Ritchey-Chrétien telescope at f/9, SBIG STL-11000 CCD camera, LRGB image with exposures of 15, 5, 5, and 5 minutes, respectively, taken October 31, 2007, at 1:36 A.M. CDT) /// **RICHARD HAMMAR, SPRINGFIELD, MISSOURI**

SOLAR SYSTEM TRAVELER

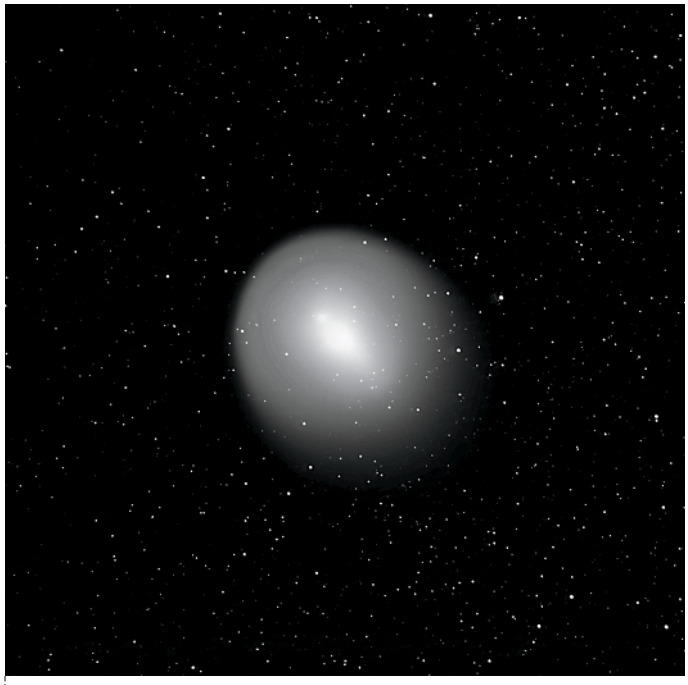
Surprise comet shines

"A million times" is a lot, even in astronomy. Imagine astronomers' surprise, then, when Comet 17P/Holmes brightened that much in just 3 days. The comet increased from magnitude 17.5 October 23 to magnitude 2.5 on the 26th. Even in cities, observers easily viewed this object, which made a right triangle with Alpha (α) and Delta (δ) Persei.

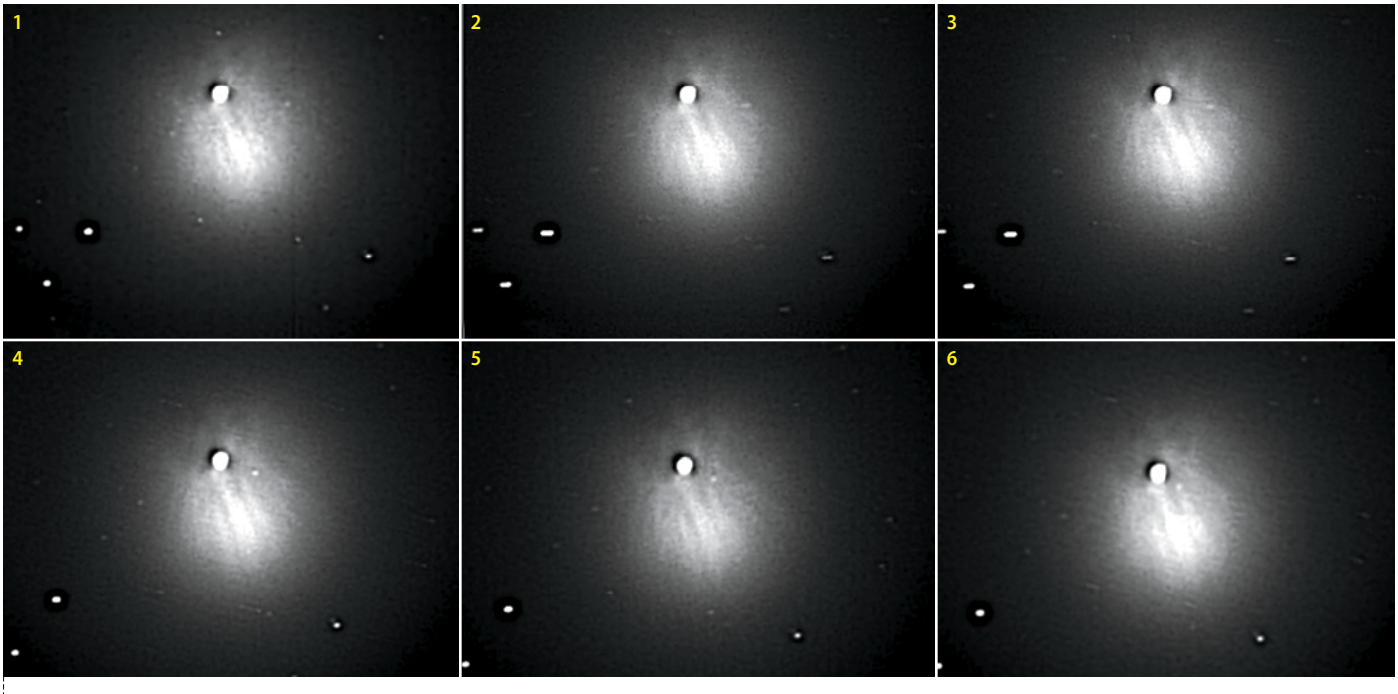
"17P" indicates Holmes was the 17th comet to have its period pinned down. The first periodic comet is the most famous: 1P/Halley. "Holmes" is the discoverer's name — English astronomer Edwin Holmes found it November 6, 1892, when he was observing the Andromeda Galaxy.

Send your images to: *ASTRONOMY* Reader gallery, P. O. Box 1612, Waukesha, WI 53187. Please include the date and location of image and complete photo data: telescope, camera, and exposure information. To submit images electronically, visit www.contribute.kalmbach.com.

THE OFTEN-PHOTOGRAPHED COMET remained in Perseus for several months after its brightness increased dramatically in October. (5-inch Tele Vue 127is apochromatic refractor, SBIG STL-11000M CCD camera, LRGB image with exposures of 8, 4, 4, and 4 minutes, respectively, taken November 5, 2007, at 12:45 A.M. EST) /// **JIM BURNELL, WARWICK, NEW YORK**



COMET HOLMES was easy to photograph even from sites that suffer from light pollution, and even through telescopes many observers consider small. (4.2-inch Astro-Tech 111 apochromatic refractor at f/7, Tele Vue 0.8x reducer, Canon 400XTi digital SLR, fifty-five 2-minute exposures, taken November 11, 2007 starting at 7:48 P.M. EST) /// **ANDY D'ARIENZO, EAST MEADOW, NEW YORK**



DETAIL IN COMET HOLMES' inner coma showed up well in images taken when the comet shone at maximum brightness. (9.25-inch Celestron Schmidt-Cassegrain telescope at f/7, SKYnyx 2.0 CCD camera, 2-second unfiltered exposures, taken October 29, 2007, at 1) 20h49m UT, 2) 21h05m UT, 3) 21h23m UT, 4) 21h45m UT, 5) 21h51m UT, and 6) 22h02m UT.) /// **DAMIAN PEACH, LOUDWATER, ENGLAND**

COMET HOLMES still glowed brightly against the stars of the Alpha Persei association more than 2 weeks after its outburst. The bright star above the comet is magnitude 1.8 Mirfak (Alpha [α] Persei). (Canon XTi digital SLR on an Astro-Physics AP1200 mount, Canon 100mm lens at f/5, ISO 800, twenty-six 5-minute exposures, taken November 10, 2007, starting at 7:30 P.M. MST) /// **CHRIS SCHUR, PAYSON, ARIZONA**

Astronomy (ISSN 0091-6358, USPS 531-350) is published monthly by Kalmbach Publishing Co., 21027 Crossroads Circle, P. O. Box 1612, Waukesha, WI 53187–1612. Periodicals postage paid at Waukesha, WI, and additional offices. POSTMASTER: Send address changes to *Astronomy*, 21027 Crossroads Circle, P. O. Box 1612, Waukesha, WI 53187–1612. Canada Publication Mail Agreement # 40010760.

ORION® OrionTelescopes.com

BEST TELESCOPE VALUES!

USER-FRIENDLY MODELS THAT WON'T BREAK THE BANK

StarBlast™ 4.5
EQ Reflector
$199.95

SpaceProbe™ 130ST
EQ Reflector
$279.95

Observer™ 70
EQ Refractor
$149.95

StarMax™ 102 EQ
Maksutov-Cassegrain
$429.95

SkyQuest™ XT8 IntelliScope®
with Computerized Object Locator
$619.95

Mars Observation
Filter, 1.25"
$44.95

New!

WorldView™
Waterproof
Binoculars
From $79.95

New!

New!

Edge-On™
Flat Field
Eyepieces
$99.95 each

32 YEARS

Sky Scout® SCOPE

A match made for the heavens!

Discover, explore and learn with the SkyScout Scope!
Designed exclusively for use with the Celestron SkyScout® Personal Planetarium®, the new SkyScout® Scope 90 is easy to set-up, nearly maintenance free and features Celestron's precision optics. Simply attach the SkyScout® to the specially designed mount to locate and identify celestial objects. Once the SkyScout® has located or identified an object it's time to take your celestial experience to the next level by using the SkyScout® Scope to reveal the wonders of the universe.

SkyScout® Scope Features:

- 90mm refractor optical design with all coated glass optics for crisp, clear images
- 660mm focal length (f/7)
- Quick and easy no tool setup
- Erect image 6x30 finderscope with quick-release bracket
- Erect image optics are ideal for terrestrial and astronomical use
- Pan handle control with clutch for smooth and accurate pointing
- Rugged pre-assembled tripod with 1.25" stainless steel tube legs provides a rigid and stable viewing platform
- Accessory tray for convenient accessory storage
- Adjustable bracket to hold SkyScout (SkyScout Personal Planetarium sold separately)

SKYSCOUT® SCOPE 90 $299

CELESTRON®
www.celestron.com/skyscoutscope

CELESTRON PREMIER SELECT DEALER

- Optics Planet – 800.504.5897 – www.opticsplanet.com
- Telescopes.com – 888.988.9876 – www.telescopes.com
- Scope City – 800.235.3344 – www.scopecity.com
- Astronomics – 800.422.7876 – www.astronomics.com
- OPT Corp. – 800.483.6287 – www.optcorp.com
- B&H Photo – 800.947.9970 – ww.bhphotovideo.com
- Adorama – 800.223.2500 – www.adorama.com

Suggested retail in U.S. Dollars. Pricing is suggested for products ordered and shipped in the U.S.A. only.